THE INFLUENCE OF VERB SEMANTICS ON SENTENCE PROCESSING

By

RUTH ANN HUNTLEY

A DISSERTATION PRESENTED TO THE GRADUATE SCHOOL
OF THE UNIVERSITY OF FLORIDA IN
PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

UNIVERSITY OF FLORIDA

1987

This dissertation is dedicated to

Rebecca Lee and Janet Fealy

without whose help, concern, sacrifice and friendship
this paper and degree would not have been possible.

ACKNOWLEDGEMENTS

Like any other major project undertaken, one needs the help of many others. I would like to thank several of these people. First of all, I would like to thank Dr. Harry Hollien for chairing this dissertation and taking a keen interest in my graduate career from the very beginning. I appreciate the professional opportunities and great knowledge that our friendship has provided me over the years. I am grateful to Dr. Leslie Gonzalez Rothi for her participation in my graduate experience and on my disseration. In particular, I value her guidance in course selection and clinical training. Finally, I am appreciative of the input that I have received from the other members of my committee--Dr. Ira Fischler, Dr. Jean Casagrande and Dr. Linda Lombardino. They were especially helpful in designing the present study and assisting in the development of the stimulus items. Without these individuals, this project would have never been completed.

In addition, several people contributed technical advice to this project. Gratitude is expressed to Tom Sawallis for his assistance in developing the linguistic stimuli. Many thanks are extended to Eric Johnson and

Robert Moy who wrote the computer programs responsible for stimulus presentation. Special appreciation is extended to Charles Brown for the computerized linguistic scoring program he wrote. I am also grateful to Charles for his friendship and many long talks about my dissertation. His insight was invaluable. Appreciation is expressed to Ken Massey for assisting in data preparation and loaning me his computer for the statistical analyses. A thank you is extended to Jim Wagener and IASCP for their assistance in preparing the graphics. Finally, I thank Ed Roepe for helping me print out the final copies of this dissertation.

The last, yet still important, group of people to thank are those who supported me as my friends. Thanks are expressed to Rebecca Lee and Janet Fealy who went through the war with me while I was working on my degree. I am grateful to Jenneine Lambert, Beree Darby and Loretta Davis for always being there for me. I appreciate Jan Calkins for her friendship and advice over the years. I am grateful to Karen Locker, Donna Ivey and Pam Paris for helping me through the last year. There are so many others who have befriended me and encouraged me throughout graduate school and I am indebted to them. Very special appreciation is expressed to my parents who believed in me and helped me select and accomplish great things. Most of all, I give thanks to my Lord, Jesus Christ, who has sustained me through it all.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Abstract of Dissertation Presented to the Graduate School of the University of Florida in Partial Fulfillment of the Requirements for the Degree of Doctor of Philosophy

THE INFLUENCE OF VERB SEMANTICS ON SENTENCE PROCESSING

By

Ruth Ann Huntley

December, 1987

Chairman: Harry Hollien
Major Department: Speech

Past research has indicated that certain linguistic cues can aid comprehension. Of particular interest are the contributions of word class and functors as they relate to verb function within a sentence. Research utilizing aphasic patients has revealed that lexical semantic variations between verb types led to increased sentential complexity. Hence, two experiments were devised to investigate this claim in normals. The first was designed to examine the influence of three verb categories--motion, directional motion and non-motion verbs--on the process of understanding. Since directional motion verbs are believed to store some prepositional information with their lexical entries, a second experiment was carried out to study the effect of varying prepositional phrase type following the

verb. Sentences were presented with rapid serial visual presentation and subject paced reading procedures. Subjects silently read each sentence, pressed a computer key when they felt that they had "comprehended" the sample and typed their responses into the computer.

The results of Experiment 1 revealed that directional motion verbs were more difficult to comprehend than motion verbs. However, not all measures of comprehension confirmed this effect as sentence recall appeared to be the most sensitive. While this outcome is suggestive of a lexical semantic processing difference, the finding that non-motion verbs were not significantly different than either type weakens this claim.

Experiment 2 demonstrated that prepositional phrases can influence processing complexity. Since both comprehension measures identified a different sentence type as being most difficult to process, similarities between the results were sought. It was determined that use of a preposition in an unexpected fashion provided discrepant cues to the reader, resulting in greater processing effort. Likewise, surface marking the implied preposition with the directional motion verb facilitated sentence understanding.

To summarize, there were differences between verbs that contributed to comprehension ease. While aphasic patients have responded to verb type in simple sentences, functor cues were effective in eliciting discrepancies

between verbs in normals. Hence, performance may break down at different points during comprehension for each group. Caution is advised in applying linguistic data obtained from brain-injured individuals to normals.

CHAPTER 1

REVIEW OF THE LITERATURE

Introduction

The study of the linguistic disability most commonly associated with a Broca's aphasia has shed light on the importance of syntactic analysis in the production and comprehension of language. Specifically, patients exhibiting agrammatism demonstrate an inability to deal with cues that facilitate linguistic analysis, in particular, those cues provided by word order and function words (von Stockert, 1972; von Stockert and Bader, 1976; Zurif and Caramazza, 1976; Zurif, Green, Caramazza, and Goodenough, 1976; Heeschen, 1980; Saffran, Schwartz, and Marin, 1980a; Friederici, 1982, 1983; Grodzinsky and Zurif, 1984; Smith and Mimica, 1984). However, inconsistent results with respect to word order processing have suggested that the influence of the verb may be a profitable area of continued research (Saffran, Schwartz, and Marin, 1980b). These investigators noted that aphasic patients seemed to have difficulty with verbs that encoded relationships as opposed to those that revealed a property

of the actor. In fact, it is these verbs (those that mark relationships) that are involved in word order and may account for the noted discrepancies. With this in mind, Jones (1984) investigated the influence of verb type in sentence processing. He found that his aphasic patients had more difficulty processing directional motion as opposed to motion and non-motion verbs. This effect suggests that the influence of lexical semantics should be considered when studying sentential complexity.

In light of Jones's (1984) findings, it was determined that clarification of these results with "normal" individuals would be appropriate and could provide information on the basic role of verb type in sentence processing. It should be mentioned however, that normal comprehension may not reflect the differences noted in language pathologies. Even so, positive findings would only substantiate Jones's results and would provide a link between the linguistic investigations conducted on normals and the brain-injured. Therefore, two investigations are proposed, each one testing an assumption of Jones. The first is an attempt to verify his findings of a processing difference between directional motion, motion, and non-motion verbs. The second is devised to investigate the influence of the preposition when processing directional motion and motion verbs, with insight into prepositional

type and prepositional case being proposed. These two studies were created to probe deeper into the lexical semantic level of processing.

Another issue that has arisen in the study of sentential complexity is how to measure comprehension. Previous investigations have utilized a paraphrase task (Fodor and Garrett, 1967; Fodor et al., 1968; Hakes, 1971) or an anagram task (Fodor et al., 1968). While these tasks frequently yielded results in keeping with sentential complexity, many researchers desired to note these processing effects on-line. Early attempts included a phoneme monitoring task (Foss and Lynch, 1969; Hakes and Cairns, 1970; Hakes, 1971) which turned out to be more sensitive to phoneme position and type of grammatical construction than to complexity. Rapid Serial Visual Presentation (RSVP) then emerged as an alternative method of testing comprehension on-line (Forster, 1970; Forster and Ryder, 1971; Holmes and Forster, 1972; Forster and Olbrei, 1973). This technique has proven to be valuable in controlling stimulus presentation time and forcing the reader to rely on his/her syntactic knowledge to structure a response. Understanding is measured by performance on a sentence recall task and errors are believed to be the result of inadequate viewing time on more difficult sentence elements. Even though RSVP has provided interesting results, the desire to have an on-line measure

of linguistic processing was still evident. One answer to this need was Subject Paced Reading (SPR) procedures. This technique provided an idea of how much time a subject spent on each word while reading (Aaronson and Scarborough, 1976; Mitchell and Green, 1978; Just, Carpenter and Woolley, 1982; Aaronson, 1984; Mitchell, 1984). Results at the paragraph level with this procedure have been encouraging. However, use of SPR and individual stimulus sentences requires further study. In summary, it would appear that sentence processing can be measured by the end-product of understanding (paraphrase or sentence recall) or on-line (in terms of reaction time data). It is possible that a combination of techniques may yield the most sensitive test of comprehension. This idea will be tested in the present investigation.

This research project proposes to continue investigation into the influence of lexical semantics on verb processing. Many of the problem areas already cited will be addressed. These include 1) type of verb, 2) type of preposition following the target verb, 3) type of prepositional phrase used, 4) measure of comprehension and 5) process of stimulus presentation. The questions will be based on the neurolinguistic findings of Jones (1984) who revealed that agrammatic patients had more difficulty processing directional motion verbs in contrast to non-directional motion verbs and non-motion verbs because

of the former's inherent prepositional information. It is realized, however, that non-brain-injured individuals may not respond in a similar fashion. Nevertheless, more basic investigations appear to be warranted.

The Use of Cues in Syntactic Analysis

Several investigations have focused on the determination of the role of syntactic constituents in sentence processing. For example, Fodor and Garrett (1967) proposed that sentence perception may be influenced by two interacting processes. These included

1) Knowledge of base structure relations into which particular lexical items can enter
2) Clues given by the lexical items which can provide insight into the types of transformations that may have occurred in sentence construction.

These investigators proposed that sentence comprehension was dependent upon recovering the grammatical relationships that existed among its parts. They studied the influence of optionally deletable items in sentential processing. Their subjects' task was to paraphrase center-embedded sentences, such as the following:

1) "The pen the author the editor liked used was new."
2) "The pen which the author whom the editor liked used was new."

The results indicated that sentence comprehension was strongly facilitated when relative pronouns were included. Hence, the processing of the second sentence proved to be easier than the first. This relationship occurred primarily because of the surface structure clues provided by the addition of the relative pronouns.

Continued investigation of surface structure influences was conducted by Foss and Lynch (1969), however, a different methodology was used to measure sentence comprehension. These investigators believed that phoneme monitoring was more reflective of on-line processing than paraphrasing because understanding was the result of interactive processing at various linguistic levels. If processing is difficult at one level, then decisions at other levels should be affected. Therefore, difficult decisions made at earlier levels of processing should slow down later linguistic processing because it is presumed to proceed in a serial fashion, i.e. from phonemics to semantics. Foss and Lynch required their subjects to listen for a particular phoneme when "comprehending" a sentence and press a button as soon as they heard the (target) phoneme. The phoneme generally would appear in the initial position of a word; however the placement of the target word within the sentence was varied and in some sentences, the target sound did not occur at all. Utilizing this procedure, these investigators hoped to

examine the difficulty of syntactic processing. They believed that complex constructions would occupy more processing capacity and increase phoneme processing time.

In the first of two experiments, Foss and Lynch selected two sentence types that varied in the complexity of their surface structure syntax: right-branching and doubly self-embedded sentences. A right-branching sentence would be as follows: "The store sold the whiskey that intoxicated the rioter that broke the window." A doubly self-embedded sentence (which has a more complex surface structure) would be: "The rioter that the whiskey the store sold intoxicated broke the window." Indeed, they did find that processing was more difficult for their subjects in self-embedded sentences than in right-branching sentences. Nevertheless, this relationship appeared only to hold true for those monitored phonemes that occurred late in the stimulus sentences. That is, there were no processing differences between these sentence types when the phoneme to be monitored occurred early in the sentence. In addition, these examiners investigated the degree of sentence comprehension during the phoneme monitoring task with a sentence completion task because they felt that it would be possible to listen only for the phoneme and not understand the stimulus. They reasoned that faster reaction times to a phoneme would result in less than 100% comprehension. However, their findings did not reveal such

a relationship between comprehension and reaction time. These investigators demonstrated that decision difficulty at one processing level could slow decision speed at another, while comprehension remains intact. Hence, use of the phoneme monitoring task to measure on-line processing was supported.

Foss and Lynch's (1969) second experiment utilized reduced and unreduced self-embedded sentences and right-branching sentences as stimuli. These sentence types were selected to analyze another surface structure cue, the relative pronoun. Therefore, unreduced self-embedded sentences contained relative pronouns, while the reduced stimuli did not. The procedure utilized was identical to the first experiment. Once again, the results could be interpreted to indicate that right-branching sentences had a shorter latency period than self-embedded sentences, however, there was no difference between the reduced and unreduced self-embedded sentences. The latter results were not consistent with Fodor and Garrett's (1967) view that surface structure cues provide insight into the deep structure. Foss and Lynch related this discrepancy to three factors. The first point is that the comprehension tests were different. The paraphrasing task used by Fodor and Garrett (1967) is more difficult than the sentence completion exercise used in the current experiments. Second, the results provided by both groups of

investigators indicate that reaction time and not comprehension supports the surface structure cue hypothesis. As such, the reaction times generated by the phoneme monitoring task appear to be more sensitive to small differences in linguistic complexity than the paraphrase task which relies on interactive syntactic processing. Finally, Foss and Lynch pointed out that relative pronouns do not always cue deep structure order, as reported by Fodor and Garrett. Hence, the generalizability of the latter experimenters' findings are limited.

Hakes and Cairns (1970) were intrigued by the above findings and attempted to compare the methods of comprehension testing previously utilized on a single set of stimulus items. They believed that paraphrasing focused on the subject's errors. Since subjects would make few paraphrase errors on sentences with easy constructions, the previous examiners devised more complex sentences in order to make comprehension more difficult. However, it could have been these very sentence types that created a greater percentage of errors on the subject's part. On the other hand, the phoneme monitoring task measured processing difficulty associated with individual words. Therefore, if one sentential component is more difficult to process, then the perception would be delayed. Based on these reasons, Hakes and Cairns proposed that the two tasks differed in

their end goals--measurement of subject errors (the paraphrase task) and processing time (the phoneme monitoring task) and for these reasons could not be considered equivalent measures of comprehension.

In their experiment, Hakes and Cairns used the same stimuli as Fodor and Garrett (1967) and included 12 grammatically complex, but not self-embedded, sentences. In addition, the placement of the monitoring word was varied and was occasionally not present. The independent variables, then, were the presence or absence of a relative pronoun, type of grammatical construction, and placement of the target phoneme. Specifically, the subject was asked to press the button when he/she heard the target phoneme and then paraphrase the sentence after it had been presented in its entirety. The results indicated that the paraphrasing was more accurate when the relative pronouns were present and there were no differences in response latency between paraphrased sentence types. Hence, when paraphrasing, surface structure cues positively affect response accuracy but do not influence response time. The results of the phoneme monitoring task also revealed a difference in the sentence types with respect to processing time. Unreduced self-embedded sentences yielded faster processing times. This finding supports Fodor and Garrett (1967), but not Foss and Lynch (1969).

Taken together, the results of the above studies reveal that there are processing differences between stimulus items. Sentence type, comprehension task, and cues provided by lexical items appear to be important factors. Interestingly, when Hakes and Cairns compared comprehension tasks, their results revealed that the phoneme monitoring task was more sensitive than the paraphrase task. Since these examiners asked their subjects to perform both these tasks simultaneously, it is possible that performance on the paraphrase task was adversely affected. While they did not resolve the issue of comprehension testing, other researchers have chosen to investigate the influence of specific syntactic units. One such area that has received attention is that of verb type.

The Influence of the Verb

Fodor, Garrett, and Bever (1968) proposed that subjects were able to maximize the influence of the relative pronoun in the Fodor and Garrett (1967) study because of their ability to appropriately analyze the verb in use. These investigators reasoned that the lexical character of the verb would be important in determining the number of possible base structures which must be considered in processing a sentence. Hence, a more complex sentence would have more deep structure configurations associated

with the main verb than would a simpler sentence. Specifically, verb complexity would be defined by the number of potential deep structures associated with it. This type of complexity can be demonstrated by the difference between purely transitive and complement verbs. Purely transitive verbs (such as "discuss") denote a single underlying structure and can dominate a direct object. On the other hand, complement verbs (i.e. "believe") have several deep structures associated with them and accept both complement structures and direct objects. Therefore, these two verb types can be used to construct sentences which differ only in the number of potential deep structures. Any processing differences could then be related to the amount of time it takes for a subject to eliminate inappropriate sentence types during comprehension.

To test this hypothesis, Fodor et al. (1968) carried out a pilot study as well as two separate experiments all of which contrasted purely transitive and complement verbs. Pilot work with doubly center-embedded sentences, such as those used by Fodor and Garrett (1967), revealed that stimulus items with complement verbs were more difficult to understand, as measured by subject performance on a paraphrasing task, than were those with transitive verbs. With these results in mind, the investigators then generated sentences that permitted two levels of

self-embedding, one with a transitive verb and the other with a complement verb. An example of these would be: "The box the man the child (knew, met) carried was empty" (the complement verb is underlined). As before, the simpler verbs (the noncomplement verbs) were reported more accurately in the subject's paraphrases. In addition, the participants were also more likely to omit a complement verb in their paraphrases.

In a second experiment, Fodor et al. (1968) constructed sentences in which the verbs differed only in their ability to accept a complement (i.e. transitive versus complement verbs). However, in all of the sentences, the function of the verb was to dominate the direct object. An example follows: "The man whom the child (knew, met) carried a box" (the complement verb is underlined). This time, the comprehension measure was an anagram task where the subject was asked to arrange given words into a meaningful sentence. These results revealed no significant differences between the complement and non-complement versions--which was not expected. This finding is particularly difficult to interpret because both the sentence structure and the comprehension task were changed. Hence, either or both could be responsible for the lack of significant differences between verb types. Even so, these investigators reported that the types of errors made during the anagram task were structurally more

serious when a complement verb was present. Complement verb errors consisted of incorrect word orders which resulted in meaningless sentences as opposed to the misplacement of an adjective or an article, as was noted with transitive verb errors. Therefore, these investigators suggested that complement verbs were more complex than transitive verbs.

Since the Fodor et al. (1968) results were equivocal, Hakes (1971) attempted to clarify the verb complexity hypothesis. Based on Bever's (1970) findings that some complement verbs could take more complements than others, Hakes proposed that the number of deep structure forms associated with a particular complement verb would influence cognitive processing load. He reasoned that if a verb could only enter into one deep structure form, it (i.e., the processing load) would be lighter than if there were several deep structure forms available to that verb. He went on to note potential problem areas with the previously cited research. The first of these involved the paraphrase task. In this case, Hakes suggested that this sort of comprehension test actually measured understanding after the sentence had been analyzed rather than assessing the processing time associated with each lexical item during the process of understanding. When using the paraphrase task, it then is possible to relate subject failures to inaccurate perceptions or paraphrase

construction difficulties. Secondly, he remarked that comprehension of doubly embedded sentences was quite difficult, especially since these types of sentence constructions rarely occur in daily language use. Hence, the unnaturalness of the stimuli could have affected past results.

With these ideas in mind, Hakes devised two experiments in which he employed more naturally occurring linguistic stimuli and included a testing procedure which he believed to be a better measure of on-line comprehension processing--the phoneme monitoring task. His two experiments utilized purely transitive verbs and complement verbs followed by words beginning with a "b" phoneme. In the first task, the verbs occurred in different syntactic structures with no embedding of phrases allowed. In the second, the position of the verb was varied to determine the effect of sentence position on processing load. Neither experiment demonstrated a verb complexity effect when the phoneme monitoring task was utilized. On the other hand, the paraphrasing task in experiment one did reveal a verb complexity effect.

Hakes provided several explanations for these findings. First, he suggested the possibility that verb structure did not influence on-line processing, but instead affected later processing (as demonstrated by paraphrase performance). Secondly, he proposed the possibility that

these tasks were too easy for the subjects and the verb structure effect did not appear. Finally, Hakes indicated that all structure decisions were made at the end of a clause. Therefore, in order to note the influence of verb type, one would have to move the target word to the next clause. Once again, method of comprehension testing and sentence type affected the results of the experiment. Nevertheless, there does appear to be some evidence for the verb complexity hypothesis. So several investigators continued this line of research, utilizing the rapid serial visual presentation (RSVP) procedure to assess on-line processing of sentences (Forster, 1970; Forster and Ryder, 1971; Holmes and Forster, 1972; Forster and Olbrei, 1973).

Rapid Serial Visual Presentation (RSVP)

RSVP was first described by Forster (1970) as a technique for the on-line measurement of comprehension. In the development of this procedure, Forster outlined two premises:

1) rapid, successive presentation of stimulus items results in a decreased capacity to organize the input.
2) the number of items correctly reported depends upon the amount of structure imposed upon the stimulus presentation.

Therefore, he reasoned that response accuracy would be greater if the subject perceives an organized whole (for example, a complete sentence) as opposed to a random string of words. In like fashion, Forster proposed that the assignment of syntactic structure would be more greatly affected in complex than simple sentences.

When RSVP is in use, the subject sees the individual words of a sentence presented one at a time--and quickly --on a CRT screen. Once the presentation of the sentence is completed, the subject is asked to write down what he/she perceived. This mode of presentation does not allow the subject adequate time to "assimilate and remember" each word, but instead relies upon the subject's knowledge of sentence structure. Hence, the ability to report the details of the sentence is enhanced if the subject can impose a "meaningful structure" on his or her perceptions. Forster also stated that the amount of information reported is dependent on two factors: the amount of structure that can be imposed upon the recognized stimulus items and the speed with which the structure is discovered. These features make this procedure useful in determining the influence of complex syntactic structures on processing.

Unfortunately, when Forster's procedure was utilized in the study of sentence processing, no definitive results were obtained. For example, Forster (1970) found that a sentence with a complement verb was easier to process than

a two clause sentence. This is in contrast to the findings of Fodor et al. (1968) who reported that complement sentences should be more difficult to process than their clausal counterparts. Moreover, Holmes and Forster (1972) found that the complexity of the verb was more indicative of sentential complexity than the number of clauses present in the target sentence. Forster and Ryder (1971) and Forster and Olbrei (1973) reported that semantic heuristics (plausibility and reversibility) did not limit the extent of syntactic analyses conducted and played a significant role in facilitating sentence processing. Therefore, like the previous studies, verb type and grammatical construction appear to be important factors in the processing load of a sentence.

While RSVP appears to be a viable method for use in measuring sentence processing, it must be realized that there is some controversy as to its actual measurement of on-line comprehension (Mitchell, 1984). For example, Mitchell was most concerned with "processing spillover" and defined this concept with respect to serial and parallel processing--i.e. the "Direct Control" hypothesis and the "Buffer Control" hypothesis. The "Direct Control" model stated that in order for a comprehension measurement to accurately reflect on-line processing, the individual must complete the analysis of the current screen without any influence from previous displays. On the other hand, the

"Buffer Control" hypothesis described how the uncompleted processing from the previous screen "spilled over" into the processing of the next. In addition, build-up of information stored in a "cognitive buffer" also could affect future processing. While holding that both processing modes could be operative simultaneously, Mitchell conceded that critics of the "Direct Control" hypothesis felt that the normal reading process would be better described by "Buffer Control" because reading is most likely a parallel processing event as opposed to serial.

Mitchell (1984) also evaluated the usefulness of RSVP in comprehension measurement. He argued that measurements using RSVP were negatively influenced by the response measure (i.e., accuracy of recall), since this is affected by factors of non-immediate processing, such as, storage, retrieval, and reconstruction of stimulus materials. In conclusion, Mitchell reported that RSVP was useful in the "fine-grain temporal control of presentation" as opposed to assessing on-line processing. He praised investigators, such as Fischler and Bloom (1980) and Forster (1981), who have effectively utilized RSVP with measures of comprehension that were presumed to be more indicative of on-line processing. Fischler and Bloom used RSVP to present stimulus sentences to their subjects, with the response measure being a lexical decision task. Here,

comprehension of the last word of the clause facilitated or hindered recognition of an individual word following it. Similarly, Forster asked his participants to repeat the last word of the visual presentation. According to Mitchell, RSVP is most reflective of on-line processing when carried out in such fashions. Nevertheless, these particular techniques reveal little about the influence of syntactic structure on comprehension.

It is proposed that RSVP could be used to reflect processing differences related to grammatical complexity when it is used to control stimulus presentation time, by not allowing the subject the opportunity to spend more time evaluating a more difficult sentence unit. There appear to be two ways to decode a stimulus sentence. The first involves identifying the main verb and generating the target sentence from a list of possible deep structures associated with that verb. The second method would involve the reverse--the participant has to rely on sentence "cues" to facilitate processing of more complex elements. Even so, both strategies involve buffer control to identify the appropriate structure when perception has been impaired. Hence, actual on-line processing may not be the most crucial component in measuring the complexity of syntactic structures, but instead the control and manipulation of linguistic stimuli may be more critical. Further research with RSVP into this area appears warranted.

Subject Paced Reading (SPR)

Researchers have proposed that giving the reader control over presentation time may be more reflective of on-line processing than RSVP (Aaronson and Scarborough, 1976). Potter (1984) has contrasted RSVP with Subject Paced Reading (SPR) and noted the following. SPR measures the amount of time the reader spends on each text segment, whereas RSVP procedures control reading time and measure target detection and accuracy and latency of comprehension test performance. Hence, SPR provides a spontaneous response to each word or group while RSVP pushes processing to the limits and measures performance breakdown. Potter proposes that SPR and RSVP measure different aspects of comprehension and taken together may provide a more accurate reflection of the temporal processes associated with comprehension. To be specific, SPR can be taken to measure the duration of some of the processing associated with a particular segment and RSVP indicates which processes are omitted because of insufficient viewing time.

Aaronson (1984) believes that studies utilizing subject paced reading should increase our knowledge of the cognitive and linguistic processes that occur during reading. She attempts to establish the ecological validity of this procedure by comparing it with the protocols

utilized to measure eye movements during reading. The first item Aaronson mentions is key pressing. In the SPR procedure, subjects press a key indicating that they are ready to see the next word. This is in contrast to the use of saccades (i.e. eye fixations) in natural reading. However, Aaronson purports that the proponents of eye movement measuring generally have to throw away "10-20%" of their data due to "saccades, blinks between words, regressions, and rereadings" (p. 103). To the contrary, SPR provides the total viewing time and has the reader look at the center of the screen (thus eliminating saccades) which is important since participants may be linguistically processing words during the periods traditionally omitted from the eye movement studies. By forcing the subject to view single words (in SPR), the examiner also eliminates the possibility of regressions to previous words, previews of upcoming words, and viewing of multiple words simultaneously. These events occur in eye movement studies and make it difficult to map visual events onto time.

The SPR procedure is more natural than a procedure such as RSVP in several important ways. Aaronson (1984) states that SPR permits the reader to read at his/her own pace. She has also determined that motor reaction times do not override linguistic reaction times. Hence, her subjects, when compared to subjects who just pressed the key but did not read the words, were found to pause

significantly longer at "linguistically important points." In addition, she also reported that the display size utilized in her studies (SD = .67/words/fixation) closely parallels that of natural reading, as compared with the measurements taken from eye movement studies. She concluded that SPR was a more natural tool for measuring cognitive and linguistic variables while reading.

SPR procedures have been used in several research protocols. Mitchell and Green (1978) carried out a series of investigations studying the influence of predictability on sentence processing. They proposed that readers should speed up reading time as they are able to predict the linguistic properties of the upcoming information. The results of the first and fourth experiments revealed that their readers slowed down on the final frame of the sentence (in this case, the last three words were presented simultaneously), suggesting that they did not interpret the phrase until the end of the sentence. Mitchell and Green concluded that reading rate was <u>not</u> a simple function of word predictability. Subjects were noted to be responsive to syntactic and word factors. They paused longer at the ends of subordinate clauses than controls and paused slightly at major breaks.

In experiments two and three in this series by Mitchell and Green, the investigators tested the hypotheses put forth by Fodor and Garrett (1967) regarding surface

structure cues (referred to as the "Cue Deletion hypothesis") and Fodor et al. (1968) with respect to different verb types (the "Verb Complexity hypothesis"). While some evidence supporting the influence of cues on processing towards the end of sentences was apparent, it did not reach statistical significance. This inconsistency with the results of previous experiments could be related to the fact that Mitchell and Green utilized simple relative clauses and not doubly self-embedded sentences as had been previously used or perhaps this effect is not apparent during on-line processing. The results of the third experiment presented no evidence that verb type affected processing; however, upon "post hoc" analysis, the examiners were able to demonstrate a "Verb Selectivity" effect (i.e. verbs that require "more specific objects linguistically"--"drink" versus "enjoy") in that readers seemed to use the verb to predict how the sentence should end. In summary, these investigators concluded that "predictive processing" did not facilitate reading and comprehension significantly and that prior context seemed to be a more influential factor. Reading rate appeared to be more affected by the time needed to access word meanings and to establish text structure.

Just, Carpenter, and Woolley (1982) set out to compare the reading times generated by various forms of a subject paced reading task with those found corresponding to gaze

durations in the eye-fixation studies. They used three conditions which differed in where the words were located on the screen and what happened to the previously presented words. The first was referred to as the "cumulative condition" and the words to be read were presented in their "naturally occurring" positions--left to right and successive lines below. In the "moving window condition," one word at a time was presented on the screen and the preceding words were replaced by dashes. For the last condition (the "stationary-window condition"), each word appeared in the center of the video screen. These investigators found that the mean reading times generated by the moving-window paradigm were the most like those obtained with gaze durations. In addition, they reported that the stationary-window condition was a close second with the cumulative condition a distant third. In conclusion, Just et al. proposed that the button-pressing methodology can produce reading times that resemble gaze duration data.

Finally, several researchers utilizing the SPR procedure have investigated the type of processing that is occurring while reading. For example, Aaronson (1984) found that there was a difference in response times depending on what type of task the reader would be asked to do once the passage was read. She noted that when reading for recall, the subjects' individual word times were more

sensitive to structure-oriented" (or syntactic processing). When reading for comprehension, reaction times were more affected by the "meaning-oriented" (or semantic) coding of the sentence.

Mitchell (1984) reported several experiments constructed to determine if SPR were under "Direct Control" or "Buffer Control." First, a series of regression analyses were carried out on the inter-response times. The only effect that reached significance was the frequency of occurrence of the current word. This suggests that the properties of preceding words do not influence the response time for the current word, thus lending support to the Direct Control hypothesis. In a second experiment, the last word was changed to a semantically anomalous one. Reading times for the last word were noted to increase, as expected; however, these times were not significantly different. When the response times to the previous words were examined, it was noted that some participants were allowing processing spillover between words (as in Buffer Control) and others were reading so superficially that they hardly noticed the incongruity. Subjects did report that they were responding before completing word analysis because they disliked the slow reading rate imposed by this procedure. So, the viewing frame was increased from one to three words and the preceding studies were rerun. This time, reading time was most influenced by the size of the

preceding display and when words were omitted from the text, subjects responded immediately to the discrepancy. In a final procedure, Mitchell tested if processing spillover existed when an optional relative clause was added or omitted. No processing spillover was noted. Hence, Mitchell concluded that the three word display was more effective than the one word display in reducing processing spillover (representative of Direct Control); however factors other than variations in display size could be responsible.

In conclusion, Mitchell (1984) lists the following advantages of the SPR procedure. First, SPR can provide an indication of how processing is distributed throughout the sentence. Secondly, effects of a relatively small display can be measured if a process can be localized to one or two words. Third, the sensitivity of the reading task can be increased by equating word frequency, syntactic structure, display size, and other items because the display size utilized is only a few words. Mitchell summed up his review of the SPR procedure by stating that this task measures on-line processing and is the least susceptible to processing spillover.

Syntactic Cues: Agrammatism

Investigators studying neurolinguistics have demonstrated the same interest in surface cues during sentence comprehension. Their findings have focused on the influences of word order and semantic influences on syntactic processing. A brief review follows. A recently postulated theory has been that agrammatism is a "word order problem" as noted by Saffran et al. (1980a). This theory was prompted by the earlier studies of von Stockert (1972; von Stockert and Bader, 1976) who looked at the ability of aphasic patients (both Broca's and alexic Wernicke's) to order simple, active declarative sentences broken at constituent and non-constituent boundaries (i.e. the "sentence order test"). The results of the initial experiment in 1972 revealed that the Wernicke's patients were able to order the constituents syntactically without comprehension of the lexical semantics in either condition. In contrast, the Broca's aphasics were only able to accurately structure sentences broken at non-constituent boundaries as they appeared to be using semantics to order the sentences. Sentences that were broken at constituent boundaries were ordered by the Broca's as NP + NP + V. To further elaborate on their findings, von Stockert and Bader (1976) took 30 German declarative sentences and asked 10

Broca's aphasics to order them. This time there were three conditions: 1) sentences broken at non-constituent boundaries; 2) sentences dependent on inflectional endings versus semantics to determine their order (an English example would be "the hare shoots the hunters" where the noun and verb agree in number, but the meaning does not coincide with real-world knowledge); and 3) nonsense sentences reliant on inflectional endings for their ordering. Broca's aphasics demonstrated a loss of grammatical capacity when ordering the sentences. These subjects tended to rely on semantics to order their sentences and would frequently alter the syntactic markers when reading their error responses aloud. In English for example, this would amount to ordering the target sentence as "the hunters shoots the hare" and reading "the hunter shoots the hare." Hence, these investigators argued that their results typified a double dissociation between syntax and semantics and supported the theory that agrammatism reflected a disorder involving the central "algorithmic" processes of syntax (Caramazza and Zurif, 1976). Notably, Heeschen (1980) provided contradictory evidence to this theory when he found that Broca's aphasics were superior to Wernicke's patients in applying algorithmic processes to "decode" sentences whose meaning was reflected in morphological cues. Nevertheless, the performance of the Broca's group declined when a competing semantic cue was

present. Hence, it was concluded that Broca's patients could apply syntactic strategies to decode sentences when forced to do so.

A variant of the sentence order test was utilized by Saffran et al. (1980a) who postulated that agrammatic aphasics had not lost the capacity to produce utterances that reflected English word order, but have instead lost the ability to accurately assign semantic relations to the position of nouns around verbs. These researchers proposed that cognitive factors like animacy and potency were more salient factors in assigning word order. Their belief is based on findings where agrammatic subjects were unable to generate the appropriate word order for subjects and objects when the possible nouns did not differ in terms of animacy. When the nouns differed in animacy, word reversals rarely occurred. Hence, animacy was believed to be utilized by the patient to indicate the position of nouns around verbs. Therefore, they proposed that agrammatic speech was generated without the underlying structures specifying logical relations.

However, Caplan (1983) sharply disagreed with the views of Saffran et al. (1980a) and by reanalyzing their data demonstrated that such patients do assign thematic relations to noun phrases (NPs) and do so in part by noting the position of the NP in the phrase or sentence. Caplan noted that the animacy relationship proposed by Saffran et

al. should hold true for all pairings involving animacy (these results were not obtained by Saffran et al. and they explained their findings as being related to a more general factor, salience). Furthermore, Caplan stated that the findings for the Saffran et al. study could be explained by a hierarchy of assumptions which were additive in their effects. This hierarchy included

1) Assume the patient is producing sentences in the active voice.
2) Assume the patient tends to put animate nouns before the verb.
3) Assume the patient tends to put nouns bearing the thematic role of agent or instrument before the verb.

In this way, Caplan demonstrated that the agrammatic patient was able to appreciate thematic notions and that the problem manifested by such aphasic patients was related to a disruption of the higher-order syntactic processes which express underlying grammatical relations.

Caplan's hypothesis has been recently upheld by Smith and Mimica (1984) who looked at the subject's ability to assign agent-object relations in a case-inflected language (specifically the nominative and accusative case inflections in Serbo-Croatian). They found that Broca's aphasics were able to more consistently assign agent-object relations when closed class morphology, semantic

constraints, and word order information were all in agreement. Therefore, it was hypothesized they understood that grammatical cues could be utilized for case assignment under certain conditions, yet the aphasics were unable to access these cues in "less than ideal" conditions.

One area within the study of agrammatism that has received particular attention is that of functor words, particularly prepositions. Zurif and Caramazza (1976) noted that aphasic patients were sensitive to differences in lexical meaning associated with functor words. This sensitivity is especially present in constructions with prepositions. They reported that their subjects utilized the information provided within the preposition to encode the semantic relations between nouns. Zurif, Green, Caramazza, and Goodenough (1976) also reported differential treatment of functors when they were critical in defining underlying structural differences between sentences. Furthermore, it has been demonstrated that Broca's aphasics display an impairment in their ability to retrieve prepositions that were obligatory and syntactically necessary while the production of lexical prepositions (those essential to conveying the appropriate meaning of a sentence) is relatively intact (Friederici, 1982, 1983). To explain this concept further, Grodzinsky and Zurif (1984) hold that it is neither the phonological nor semantic properties which determine the obligatoriness of

the preposition, but it is the relationship of the preposition to the main verb which is of particular importance. Once again, research attention is drawn to the verb and its influence in determining sentence structure. The relationship between verbs and word order has been postulated by Saffran et al. (1980b) and was recently tested by Jones (1984).

Lexical Semantic Analysis of Verb Types

If word order was responsible for the difficulties noted in processing grammatical relationships by aphasic patients, Jones (1984) proposed that the verb may be responsible. He wanted to determine if directional motion verbs were more difficult than motion and non-motion verbs for aphasic patients to process. These verb types have been previously described by Miller (1972). Unlike the contrast between transitive and complement verbs used in past research, these verbs vary in the complexity of their lexical entries. On the other hand, the contrast between transitive and complement verbs is primarily a syntactic variation. To be specific, directional motion verbs not only encode an active and directional relationship between two nouns, but they also imply a particular preposition that reflects the directional component. Hence, this verb

type should be more complex than a simple motion verb, which only describes the action of the sentential subject.

In the Jones (1984) experiment, simple active reversible declarative sentences (NP V NP) were used and a comprehension and production task were devised. The comprehension task consisted of three pictures--the target, role reversal, and different verb (different category) picture. A sentence was read aloud to the aphasic individual and he/she was asked to select the picture that best represented the given sentence. It was revealed that the agrammatic patients had greater difficulty processing the stimulus items containing the directional motion verbs, with no significant difference noted in the processing of motion and non-motion verbs. A sentence order test (as described by von Stockert, 1972) was utilized as the production task. Here, the subject was asked to arrange the constituents of a sentence into the proper order to describe a picture. However, in the production task, this processing difference between verb types was not noted. In discussing his results, Jones suggests that the participants were aware of the correct verb because they frequently rejected the distractor picture. He believed that the subjects were able to abstract certain aspects of meaning which differentiated the verbs; however the errors noted suggested that the patients were unable to ascertain information helpful in mapping the predicate/argument onto

the grammatical structure. Jones then postulated that the verb alone would determine the processing difficulty associated with the noun arguments. Hence, directional motion verbs were deemed to be more difficult because they required processing of action and directionality in determining the relationship between the nouns.

In a second group of experiments, Jones (1984) investigated his hypothesis that the increased processing time noted with directional motion verbs was related to the presence of an embedded preposition (located in the individual's lexicon) which marked directionality. Jones's hypothesis was that failure to process the prepositional information inherent in the lexical entry resulted in the greater number of processing errors associated with directional motion verbs. Hence, placing this directional preposition in the surface structure of stimulus sentences should result in reduced processing effort and this is exactly what was found. This type of sentence construction resulted in near normal processing of directional motion verbs by agrammatic individuals. Therefore, in summary, Jones found the following:

1) Agrammatic patients have defective comprehension of word order in simple active reversible declarative sentences;
2) The cited difficulty is related to particular verbs --i.e. directional motion verbs; and

3) The problem seems to reside in the complexity of the predicate structure of these verbs.

Jones then postulated that the problem must lie at the lexical semantic level (and not only a syntactic level) because of the aphasic patient's failure to utilize essential prepositional information. These findings are of particular interest because insight into the link between syntax and semantics is provided. However, his results are only reported for neurologically impaired individuals. Therefore, Jones's ideas need to be assessed with normal language users before any conclusions can be drawn. Hence, the following experiments are designed to investigate the lexical semantic impact of verbs on sentence processing.

Objectives

Jones (1984) stated that the properties of verbs in English can determine the relationship between grammatical structure and semantics. Other investigators (Jackendoff, 1972; Gruber, 1976; Bresnan, 1978) support this view by describing how the link between syntax and semantics relies upon the lexical information attached to specific verbs. This description specifies the semantic roles (or cases) that the accompanying nouns can play depending upon the speaker's (or writer's) intent. Jones illustrated his point by contrasting "push" with "pull." He stated that

both verbs described similar actions; however, they differed in terms of the embedded preposition ("push" = NP2 ahead NP1 and "pull" = NP2 behind NP1) and in the way thematic roles were assigned to the syntactic relationships. Verbs, such as "push" and "pull," are hypothesized by Jones to be more difficult to process because they possess an embedded predicate (i.e., the prepositional predicate is embedded in the verb predicate). However, this hypothesis has only been evaluated with regard to aphasic individuals and warrants further testing in normal populations.

While experimental findings from language impaired subjects can demonstrate the separation of certain language processes, they should not be used to definitively assert that normal linguistic operations proceed in like fashion. It is possible that brain injury, resulting from the disruption of cognitive processing, may also force the brain to operate in a non-standard fashion. For instance, the patient may be using strategies that are invoked by compensatory language mechanisms or he/she may even be experiencing cortical operations that are the result of brain damage. Therefore, the assumption that abnormal language behaviors represent fractionation of the normal process is not an accurate one. Hence, it is the purpose of this investigation to attempt to simulate lexical semantic processing in a population of normal college-age

students. Cognitive processing will be tested with two experiments aimed at demonstrating a complexity difference between specific verb types.

Another important factor in the processing of sentences is the degree of semantic constraint that is indicated by the lexical items included and the order in which the words are used in a sentence. Reversibility, plausibility and word order are basic strategies for determining the desired internal relationships between items within a sentence (Bever, 1970). For example, given the sentence, "The man fixed the door," one can easily deduce that it was the man who was doing the fixing and this judgement can be based simply on world knowledge. If the subject and object positions were reversed in this sentence from the traditional S-V-O order, it would not pose much of a challenge to comprehension. In other sentences however, the order of the subject and object can be reversed, a situation which can prove to be troublesome when passive sentences are to be decoded (Slobin, 1966; Schwartz, Saffran, and Marin, 1980; Saffran, Schwartz, and Marin, 1980a). In these cases, it has been observed that young children and agrammatic adult aphasic patients tend to rely only on word order--as opposed to syntax--to derive sentence meaning. Hence, reversibility requires the more mature language user to rely on relatively complex sentence processing strategies in order to insure accurate

comprehension. However, the present experiments only utilized irreversible sentences because it was not possible to generate an equal number of reversible sentences for all verb types. In addition, only meaningful (plausible) sentences were used--that is, excepting for the 20 nonsense sentences that were included in each experiment as foils.

The present project considers Jones's (1984) claims regarding lexical semantic processing. In his work, he noted a comprehension difference between three verb types which seemed to be related to the complexity of the verb's predicate structure. This difficulty is related to the lexical specifications of the particular items, which in this case included motion, directional motion and non-motion verbs. Miller (1972) defined motion verbs as specifying motion between two objects, whereas directional motion verbs not only indicated that motion was present, but that this motion occurred in a <u>specific</u> direction. In turn, this specific direction was encoded with the verb in its lexical entry by the association of a particular preposition. For example, the verb "enter" also carried with it the idea of "in." Another interesting feature of this type of verb is that the implied preposition can be present in the surface structure of a sentence, but usually will not. Hence, motion verbs occur in relatively simple verb phrases. However, directional motion verbs create

more complex syntactic elements, ones that imply a preposition and a direction of motion in its use.

To better illustrate the contrast between motion and directional motion verbs, Jones (1984) included the category of non-motion verbs, a class of verbs which is characterized by lack of motion. Syntactically, non-motion verbs should behave like motion verbs. Hence, the only difference between these two types would be semantic. Adding such a control emphasizes the lexical semantic contrast between motion and directional motion verbs; hence the observed differences between these verb types would be more syntactic in nature.

To test his ideas about lexical semantic verb categories, Jones (1984) utilized both receptive and expressive tasks and a group of aphasic patients. His results indicated that directional motion verbs were more difficult to process than the other verb types. Also, he determined that motion verbs and non-motion verbs were processed with equal difficulty. While these findings suggest a processing complexity associated with directional motion verbs, this relationship needs to be verified in a "normal" population. Hence, the first experiment to be carried out presently will assess these conclusions in a group of college-age subjects utilizing traditional sentence processing tasks and comprehension measures.

It is possible that the first experiment will not be sensitive enough to detect verb type differences; therefore a second study will be carried out to further investigate the concept of a complex predicate structure. In like fashion, Jones (1984) tested the influence of the implied preposition on the processing of directional motion verbs. He reasoned that his aphasic subjects had difficulty with this verb type because of their inability to access the implied preposition--a relationship that could be expected especially in agrammatic individuals. Therefore, he believed that if he placed this functor in the surface structure of his test phrases, the processing of directional motion verb sentences would be facilitated. His hypothesis was supported in that Jones was unable to demonstrate a verb type discrepancy. Hence, the inclusion of the implied preposition improved sentence processing. While these findings are suggestive of a syntactic disturbance in his subjects, a similar test in normals may provide a more sensitive measure of the processing difference between verbs.

Accordingly, a second experiment will be completed to test the influence of prepositional cues. In this case, it is proposed that the implied preposition associated with a directional motion verb also will implicate the use of a directional phrase. Therefore, if this functor is surface marked in the test sentence, the reader would expect the

prepositional object to be a direction. Processing of this sentence type might be easier than a stimulus item using the same preposition in a non-directional sense or using a different (or non-implied) preposition in both directional and non-directional phrases. When compared with performance on similar constructions utilizing motion verbs, one may gain greater insight into the influence of verb semantics on syntactic analysis during reading.

In order to elicit the proposed difference in sentential complexity attributed these verb types, this researcher had to make numerous decisions relating to method of comprehension testing and stimulus presentation technique. To answer these questions, a review of the past sentence processing literature becomes essential. To be specific, some investigators have used a paraphrase task (Fodor and Garrett, 1967; Fodor et al., 1968; Hakes, 1971); others an anagram sentence task (Fodor et al., 1968) to assess understanding. However, many investigators have judged that tasks such as these were not representative of on-line comprehension processing but, instead, reflected the end-product of understanding. For example, they believed that paraphrasing required storage, retrieval and reconstruction of the stimulus items, all of which (in turn) required memory activation and were subject to error. To measure a different aspect of comprehension, the use of a phoneme monitoring task was suggested. This type of

measure was presumed to be more reflective of immediate comprehension processing (Foss and Lynch, 1969; Hakes and Cairns, 1970; Hakes, 1971). Even so, the results from these studies were discouraging because the majority of the researchers did not find the desired processing differences --those reflective of sentential complexity. Hence, they suggested that phoneme position and type of grammatical construction might be more influential factors than previously assumed by linguistic theory.

Next, examiners began using rapid serial visual presentation (RSVP) procedures and sentence recall to measure on-line perceptual complexity (Forster, 1970; Forster and Ryder, 1971; Holmes and Forster, 1972; Forster and Olbrei, 1973). Once again, the results were affected by semantic factors and type of grammatical construction, making it difficult to attribute the desired processing findings to sentential complexity alone. Finally, some researchers have attempted to simulate the on-line processing results that could be obtained during eye movement studies by allowing the subject to control stimulus presentation time. Use of the Subject Paced Reading (SPR) procedure provides an idea of how the processing load is distributed throughout the sentence (Aaronson and Scarborough, 1976; Mitchell and Green, 1978; Just, Carpenter, and Woolley, 1982; Aaronson, 1984; Mitchell, 1984). While this method has been shown to be

sensitive to grammatical complexity in text, it has not been tested as frequently at the sentence level as the above techniques. Hence, its utility needs to be assessed.

It was determined that the use of less complex sentences would more accurately demonstrate a difference attributable to verb type. Therefore, task sensitivity and measure of comprehension testing became important considerations. Since it was possible that the desired discrepancy between verb types may be present during sentence processing, both RSVP and SPR procedures were selected as different approaches tapping on-line comprehension. The measure here would be the reaction time corresponding to when the subject believed he/she "understood" the sentence or individual word presentations. In addition to these measures, sentence recall and an error type analysis should provide information regarding the end-product of comprehension. Hence, while no particular method of comprehension testing or stimulus presentation technique has surfaced as the most effective, it is proposed that careful control of linguistic stimulus material, subject selection, and use of multiple comprehension measures may yield the desired sensitivity.

Specific Goals

The interaction between syntax and semantics in the comprehension of sentences requires continued study. Such knowledge could aid both psychologists and linguists alike in their understanding of the influence of the verb semantics in determining sentence structure. In addition, there would be an applied aspect of this knowledge. Considering the increasing number of head injury victims in rehabilitation today, such knowledge could lead to improved treatment programs for reading comprehension. However to date, the research findings in sentence processing have been contradictory. Nevertheless, it may not be the ideas that are in error, but the sensitivity of the measurements and the control exercised in devising the tests, instead. Hence, further study in this area will be carried out.

The two experiments to be conducted will provide a comprehensive evaluation of the influence of the verb on sentential complexity. This also will test (and hopefully replicate) the findings reported by Jones (1984). As indicated, the first experiment will assess the processing difference between three verb types, while experiment two provides a more sensitive test of Jones's (1984) "influence of the preposition" assumption. In both tasks, sensitive stimulus presentation techniques and comprehension testing

methods have been selected. Specifically, answers to the following questions are sought:

1) Is there a processing difference between verb types?
2) Is there a processing difference attributed to prepositional phrase type?
3) Is processing complexity best demonstrated by response latency or accuracy?
4) Is there a difference in sensitivity between the processing procedures (RSVP versus SPR)?
5) Is there a difference in sensitivity between the accuracy measures?

These findings are significant in that they demonstrate the link between syntax and semantics that is often discussed (in terms of parallel processing) when an experiment or task fails to yield the results expected if the premise of syntactic autonomy is true (Just and Carpenter, 1987). Furthermore, since this proposal seeks to compare aphasic to normal linguistic performance, insight can be gained as to the similarities and differences between how these populations process language.

CHAPTER 2

METHOD

Two experiments are proposed which permit examination of the influence of verb type and complexity of predicate structure on sentence processing. In the first experiment, contrasts among directional motion verbs, motion verbs and non-motion verbs in sentences will be evaluated, while the second study will be focused on the processing differences between types of prepositions (implied versus non-implied) and cases of prepositional phrases. All stimuli will be presented as sentences and viewed by participants by means of Rapid Serial Visual Presentation (RSVP) or Subject Paced Reading (SPR) procedures. Briefly, the subjects will be asked to silently read each sentence (as it appears on a computer screen) and when the sentence presentation is complete to write out the sentence as they perceived it. Response latency and two methods of assessing written response accuracy will be the dependent measures. It is hypothesized that there is a cognitive processing difference in verb types as noted in the aphasic populations previously tested by Jones (1984) and that this

processing difference is related to the prepositional information that is presumed to reside in the lexical entry for the verb.

Subjects

Sixty-four young, healthy adults (32 males and 32 females) with no known history of reading disability served as subjects for these investigations. Subjects' ages ranged between 17 and 29 years (mean age = 20.04 years)--an age range selected because of subject availability and in order to permit comparison of the results from this project with those from other (similar) studies. Since two separate experiments were conducted, subjects were subdivided into four generally equal groups of sixteen (eight men and eight women) with groups randomly assigned to each experiment. All volunteers (i.e., potential subjects) also had to be able to type and to meet specified medical, visual and reading level criteria before they could qualify for participation in either project.

The medical selection criteria included no history of neurological disease, no cerebral insult or high fevers, lack of seizure activity, and no anti-convulsive medications currently being taken (see Appendix A for medical questionnaire). This information permitted elimination of any candidates who may have had a

neurophysiological reaction to the stimulus presentation method (RSVP or SPR) (i.e. the seizure prone). These (subject) data also could have suggested possible developmental or acquired reading disorders. Subsequently, all subjects were screened for adequate visual acuity (with glasses or contact lenses, if needed). The Titmus Vision Tester (Titmus Optical Co., Inc., 1968) was utilized for this purpose. This instrument is designed for stereoscopic measurement of visual acuity. Each subject rested his or her forehead on the headpiece and looked into the lens and saw a slide. Response to this slide determined visual acuity in Snellen equivalences for both eyes. The volunteer saw 14 individual sets of four circles, only one circle was solid. He/she was asked to identify which circle was unbroken by stating right, left, top, or bottom. No subject with vision poorer than 20/40 (corrected) was allowed to participate. Testing for the visual acuity of each eye individually was not necessary since the research task utilized bilateral vision.

Subjects' reading skills were assessed by administration of the reading test from the McGraw-Hill Basic Skills System (Raygor, 1970). Subject performance on this test yielded both a reading comprehension level and a measure of reading speed during a timed (reading) passage. Only Part 1 of this test was utilized since the information necessary for this project (reading level and speed) could

be collected from the administration of this subtest alone. As would be expected, the test was administered according to specified procedures. Specifically, the participant was asked to read the passage for three minutes. Subjects marked their place when they were asked to stop and then continued reading for two more minutes before answering ten comprehension questions listed on a separate page at the end of the paragraph. The subject had three minutes to answer these questions and he/she was not allowed to look back at the paragraph when answering them. This same procedure was followed for administration of both an easy and difficult passage. The entire procedure took about fifteen minutes to complete. Only those subjects who achieved a 50th percentile minimum reading competency were included in the experiments. This criterion was applied in order to insure that all subjects could adequately perform the required tasks. Fifteen subjects failed to reach this minimal reading criterion (5 males and 10 females). In addition, the data from two female subjects were discarded; the first because of equipment malfunction and the second due to an excessive number of missing data points. Hence, a total of 81 subjects were run in order to achieve the necessary 64 participants with good reading skills. While reading speed was not utilized in subject selection, these data were calculated for possible use in normalizing the reaction time data before statistical analysis.

At the beginning of a session, the subject was asked if he/she could type (typing speed was not important). Only those individuals who could were utilized, since subject responses were typed into the computer. This control also suggested that the volunteer was familiar with the computer keyboard and avoided the awkwardness involved in pushing a key for response latency and then writing the response on paper. Finally, demographic information was collected on all subjects. The questions included name, address, phone number, age, and birthdate. As stated, this form and the subject informed consent may be found in Appendix A.

Experiment 1: Verb Types

The first experiment is simply the test of the three verb types: non-motion, motion and directional motion verbs. However, this would not be accomplished in the same fashion as the Jones (1984) study. In his work, Jones used a picture comprehension task and the sentence order test to demonstrate the receptive and expressive disability. It was determined that such tasks would be too elementary for normal individuals and would not yield the desired processing difference. Therefore, it was determined that

techniques more commonly utilized in sentence processing tasks could be implemented in hopes of eliciting a difference in sentential complexity.

This experimenter, like Hakes (1971), felt that it was important to test for such a difference in simple sentences and avoid the possible introduction of an additional variable by utilizing more complex sentence types. Additionally, the desired effect was deemed to be more conducive to a reading procedure. Therefore, in order to meet these preferences, the examiner was obligated to pick a stimulus presentation procedure that was both natural (i.e., like the actual reading process) and sensitive. Hence the Rapid Serial Visual Presentation (RSVP) procedure (Forster, 1970; Forster and Ryder, 1971; Holmes and Forster, 1972; Forster and Olbrei, 1973) was selected as being the most effective in controlling stimulus presentation time and forcing the reader to rely on syntactic/semantic processing to fill in the gaps (Forster, 1970; Mitchell, 1984). Comprehension would then be tested after presentation of the stimulus item. In conjunction with the RSVP task, an on-line measure of comprehension (SPR) was included should the former task not prove to be sensitive enough. The SPR technique yields responses to individual words in a sentence and should provide insight into how the processing load of the sentence is distributed (Aaronson and Scarborough, 1976;

Mitchell and Green, 1978; Just, Carpenter and Woolley, 1982; Aaronson, 1984; Mitchell, 1984). An added benefit of using two procedures for stimulus presentation was the opportunity to compare the results of one with the other.

Finally, the reaction time data generated by both the RSVP and SPR protocols were not the only measures of sentential complexity taken. The subjects were also asked to write down the sentence they had just read. Sentence recall provides a measure of comprehension that represents the end process of reading; the synthesis of pupillary responses, on-line linguistic processing and memory to name a few. This measure was deemed necessary to encourage the participants to actually read what they were seeing as opposed to non-chalantly pressing the key to indicate processing. These data should verify the reaction time responses; however, they are not always in agreement (see Hakes and Cairns, 1970). Therefore, it seems to be important, in light of the past sentence processing literature to investigate the comprehension abilities assessed by these two measures. Finally, this investigator decided to score the linguistic accuracy of the subject's typed responses in two ways. The first would be a straight word count--the number of correct words recalled in the correct order. This measure is the one most commonly utilized in past projects. In addition, a simple error analysis was conducted. With this procedure, an error

severity score was generated and it was possible to highlight the frequency of certain error types. The use of the above listed procedures should tap into a difference between the lexical semantic verb categories if such a difference can be detected. A listing of the particular stimulus presentations to be employed in this experiment is found in Appendix B.

Experiment 2: Influence of the Preposition

The second experiment builds on the first by attempting to analyze Jones's claims in greater detail. It was conducted like the first in terms of stimulus presentation techniques and response scoring. The difference between the two experiments lay in the linguistic stimulus items themselves. Jones (1984) postulated that his aphasic subjects had a greater degree of difficulty with directional motion verbs because of the implied preposition that is believed to reside with the verb in its lexical entry. The presence of this inherent preposition results in the prepositional predicate being embedded in the verb predicate during processing. In an attempt to test this hypothesis, Jones placed (i.e., surface-marked) the implied preposition in the target sentence with its directional motion verb. He found that the brain-injured patients were now able to process the

directional motion verbs as easily as other verb types. Furthermore, Jones asserted that this finding verifies his premise that a degree of syntactic complexity resides at the lexical semantic level of processing.

To test this premise, it was decided that the following stimulus types could be utilized: directional motion and motion verbs. Furthermore, the type of preposition and prepositional phrase could be altered to determine their influence in the noted effect. So, both implied and non-implied prepositions were utilized to detect the effect of surface marking the inherent preposition. The type of prepositional phrase associated with the verb (directional versus non-directional) was also assessed. It is proposed that surface-marking the implied preposition should reduce the complexity associated with a directional motion verb. Therefore, processing should be facilitated. However, since a directional motion verb can occur in print (and frequently does) with another preposition, it also seems logical to test out the influence of the preposition. Hence, the contrast between implied and non-implied prepositions was established. Continuing in this line of thought, the experimenter determined that it would also be of interest to test the effect of the type of prepositional phrase. Again, this could be broadly divided into two types: directional and non-directional phrases. Specification of prepositions and

phrases in this way does suggest a hierarchy (if in fact Jones's premise is correct) with the directional motion verbs with the implied preposition and directional phrase being the least complex because of their inherent redundancy and the directional motion verbs with the implied preposition and non-directional phrase as being more difficult, at least in terms of not meeting the reader's expectations. It is difficult to rank the other types, but it is believed that the directional motion verb combinations should be more complex and the motion verb categories should not reflect a processing difference, at least one that could be attributed to lexical semantics.

As described, this experiment permited assessment of the processing differences between prepositional type and prepositional phrase case. As in the first experiment, the stimulus items used here formed 80 unique sentences utilizing 20 different verbs. Once again, directional motion verbs and motion verbs comprised the stimuli. Examples of stimuli to be used in this experiment also are included in Appendix B. In short, use of these types of stimuli allowed comparison of verb type and if this varied with prepositional type and case.

Sentence Construction

All sentences for the above experiments were constructed in response to the criteria specified as follows. First, sentence length was controlled. All stimulus sentences consisted of nine words, a length that was selected because it exceeded immediate memory (Miller, 1956). This sentence length should force the subject to rely on some syntactic processing in sentence reconstruction, as opposed to simply memorizing the visual display. Secondly, sentence difficulty was controlled throughout all sentences--specifically so that all sentence vocabulary consisted of frequently occurring words (i.e., those that occur at least once in 500 samples). For these purposes, the work of Francis and Kucera (1982) was utilized. Third, sentences were in the past tense and structured to indicate a single rather than continuous event. Fourth, all sentences in Experiment 1 conformed to a N-V-N sentence frame; those in Experiment 2 were intransitive with the verb being immediately followed by a preposition. Fifth, sentential elements were added to the specified verb and sentence types, that affected the meaning of the entire sentence and not an individual element alone. Finally, sentence beginnings were diverse and sentences were semantically natural.

Each verb type included 10 different representative verbs. To control for the possible influence of semantic constraint, each of these verbs was presented in two or four different sentences (depending upon the experimental condition). For Experiment 1 only, the sentence frame was held constant and the verb type manipulated. In this way, sentential semantics were controlled, strengthening the claim that any noted effect could be attributed to the verb type alone and not to differences in the semantics of the sentence. This approach resulted in a total of 60 sentences. In Experiment 2, each directional motion verb (DMV) was used to formulate four different sentence types which, in turn, were utilized to examine the influence of prepositional type and case. The sentence types represented included

1) DMV with implied preposition in directional case
2) DMV with implied preposition in non-directional case
3) DMV with non-implied preposition in directional case
4) DMV with non-implied preposition in non-directional case

Motion verb sentences were constructed following the same design. However, since motion verbs do not have an implied preposition in their lexical entry, the examiner selected a preposition that was presented in both a directional and non-directional sense. Then, different prepositions were utilized for the directional and non-directional cases in

the final two sentences (i.e., the non-implied preposition in the case of directional motion verbs) of both verb types. These procedures resulted in 80 stimulus items.

In order to insure that each subject responded to the sentence as he/she perceived it, as opposed to forcing every stimulus presentation into a particular sentence form, 20 nonsense sentences also were included in each experiment. Hence, the total number of sentences presented to each subject in Experiment 1 was 80 and 100 in Experiment 2. The meaningless sentences were constructed with real words, but word order did not conform to that of standard English. Verbs included in these nonsense sentences were selected at random from other motion and directional motion verbs identified by Miller (1972). Half of these stimuli could be rearranged into meaningful sentences and the other half were totally nonsensical. This control acted as a check, allowing the investigator to see if the subject was forcing all stimulus presentations into a meaningful sentence form. Then, all sentence types were quasi-randomized within the experiment and formed two different lists randomly which were presented to the subjects. This minimized the effects of reader irritability and fatigue.

Procedures

Stimuli Presentation

Two methods of stimulus presentation were compared and contrasted. These included rapid serial visual presentation and subject paced reading procedures. The rapid serial visual presentation (RSVP) procedure as described by Forster (1970) was used to determine "on-line" sentential processing. Briefly, the words of each stimulus sentence are presented individually on a CRT screen, so fast (approximately 50 msecs.) that they cannot easily be "assimilated and remembered" by the subject. The individual is then asked to recall what he/she perceived. Therefore, the ability to report the details of the sentence is enhanced if the subject can impose "meaningful structure" on his or her perceptions.

The subject paced reading (SPR) Task as described by Mitchell (1984) resembles RSVP; however the subject now has control over how long the visual display remains on the CRT screen. Individuals are asked to press a key as soon as they recognize the current word. Once the key is pressed, the next word appears. Participants were urged to not memorize each display since they could look at it as long as they desired. The interval between key presses is assumed to reflect the amount of immediate processing time

associated with a particular lexical entry. Mitchell reports that the SPR procedure has many of the benefits of eye-movement studies without the cost and difficulty associated with running eye-movement experiments. For example, the SPR procedure allows analysis of how the processing load is distributed throughout the sentence and it can localize heavy processing demands. In this way, SPR increases the sensitivity of the task and the likelihood of picking up subtle experimental effects.

A PDP 11/23+ mini-computer was utilized in the administration of the RSVP and SPR procedures. The computer program used to control stimulus presentations conformed to the following specifications. Letters were white on a dark screen. Stimuli were lower case with the first letter of the first word in the sentence capitalized. The letters were 1.6 cm high and between 0.3 to 0.5 cm wide. In the RSVP procedure, all items were presented individually on the screen for approximately 50 milliseconds. Subjects had control of the presentation time in the SPR procedure. To begin each sentence trial, a dark screen appeared followed by a "Ready" prompt (lasting approximately 250 msec) warning the subject that the trial was about to begin. At this juncture, the screen darkened for 100 msecs and the sentence presentations commenced. There was a 25 msec. pause between word presentations (in both conditions) to allow the screen to darken before the

next word was shown. Once a sentence was complete in either procedure, two lines appeared on the screen to signal the end of the current stimulus display.

Experimental Task

Each subject was tested individually, seated in front of a computer screen. He/she was instructed that groups of words would be appearing rapidly on the computer screen. Additionally, he/she was told that some of these presentations would create meaningful sentences and others would not, but that the task was to type exactly what was seen. A familiarization procedure was carried out before the experimental stimuli were presented. Five practice sentences were displayed for this purpose: one was a nonsense sentence and the other four represented sentence types utilized in either experiment. A practice set was generated for each of the conditions. When the subject was ready, he/she pressed the carriage return. After viewing a stimulus presentation and when ready to respond, he/she deactivated the program by hitting the space bar and typed the perceived sentence. Once completed, a subject pressed the carriage return to initiate the next sentence presentation. The first ten responses to the practice stimuli were scored for the subjects that participated in the RSVP task. Only those subjects that maintained a 75%

accuracy level were to be utilized. Poorer performance on this task suggested that the visual presentation time may be too fast for the participant; thereby creating errors. Actually, no subjects failed to meet this criteria.

Analysis

Subject responses were analyzed in three ways. These scoring methods included response latency and two techniques assessing response accuracy--word-for-word matching and point deductions for specific error types. In these ways, the investigator was able to analyze differences in terms of latency (corresponding to cognitive processing) and accuracy (reflective of processing difficulty). A brief description of each scoring method follows.

Response latency was included as an estimate of sentence processing time. This factor for the RSVP procedure was obtained by computer calculation (in milliseconds) of the period from when the two lines appeared on the screen (end of stimulus presentation) to when the subject pressed the space bar (signal of intent to write a response). These temporal measurements were used to determine if a processing difference existed between the various sentence types. The latency responses differed in the SPR task. Here, the computer measured (in

milliseconds) a latency for each individual word. The researcher believed that the only latency scores of interest would be associated with the target verb in Experiment 1 and the target verb, preposition, and prepositional object in Experiment 2. These procedures should identify which sentential elements were the most difficult to process, based on how long a subject views a particular word.

A computerized linguistic analysis program was written to score the subjects' typed responses. The program took each answer and compared it to the target response, generating the following information

1) Word length of stimulus
2) Word length of response
3) Number of correct words in response
4) Number of correct words in correct order
5) Nonstimulus words in response
6) Number of omissions
7) Number of additions
8) Number of duplications within the response
9) Displacements as found in response
10) Number of reversals

The first three items are self-explanatory and provide information regarding basic characteristics of the subject's response. The word length of the stimulus was always nine, while the word length of response indicated

how many words the individual remembered. The number of correct words in the response gave an idea of how many words were recalled regardless of their order in the answer. Item number 4, number of correct words in the correct order, provided the first score of linguistic accuracy. This measure has been quite frequently utilized in previous sentence processing experiments. It was determined by programming the computer to locate the longest sequence of correct words in ascending order. For example, if the stimulus were "Mary's new boyfriend forgot red roses for her birthday" and the subject response was "Red Mary's new boyfriend forgot birthday her roses," then the score for number of correct words in the sentence would be eight, but the number of correct words in the correct order would be five.

The second linguistic accuracy score reflected the severity of the errors that occurred in the participant's response. This was calculated by assigning one point to each error within particular types that occurred and then summing the points to achieve a total severity score. It was determined that the combination of nonstimulus words in response, number of omissions, number of additions, and displacement as found in the response would provide a fairly comprehensive picture of error severity. The number of nonstimulus words in the response was generated by counting the number of words that did not occur in the

stimulus but did occur in the response. Omissions were computed by subtracting the number of words in the response from the number of words in the stimulus, if the former was less than nine. If the number of words in the subject's answer was greater than nine, then the number of words in the stimulus was subtracted from the number of words in the response providing the number of additions. Finally, the number of displacements from the target position was calculated in the following manner: each word in the stimulus and response was numbered and then compared with the number of the position in which it actually occurred. For example, given the same sentence as before, "Mary's new boyfriend forgot red roses for her birthday" and the subject response "Red Mary's new boyfriend forgot birthday her roses," the computer would proceed as follows:

1 2 3 4 5 6 7 8 9

S = Mary's new boyfriend forgot red roses for her birthday.

R1 = Red Mary's new boyfriend forgot birthday her roses.

1 2 3 4 5 6 7 8

The numbers above and below these sentences represent the order in which the elements occurred in the stimulus and response. Next, an order based on the position of words in the response was derived. This order was not based on the position of stimulus items because of the double penalty that would result when words were omitted from the subject's response. Hence, the response ranking would be:

R2 = Red Mary's new boyfriend forgot birthday her roses.

5 1 2 3 4 8 7 6

Now, the two sets of numbers representing response order were subtracted from one another (and the absolute value taken) and added together to achieve a displacement score. So, 4 + 1 + 1 + 1 + 1 + 2 + 0 + 2 = 12. This score is designed to provide an estimate of how jumbled the sentence became during recall.

The final two categories of errors were used to specify certain mistakes that could be related to memory failure; such as number of duplications and number of reversals. Duplications referred to the "extra" occurrence of a stimulus word in a sentence. Specifically, the duplication score would be one if the word "the" occurred in a response three times and it was only supposed to occur twice. A reversal was defined as the juxtaposition of two adjacent words. It was believed that this form of linguistic analysis of the subject's responses would provide greater insight into the types of errors (and their severity) that were made during the RSVP and SPR procedures. Appendix C provides a sampling of this type of linguistic analysis.

These latency/accuracy responses were analyzed in terms of several factors. As stated, the independent variables for Experiment 1 were verb type (directional motion versus motion and non-motion verbs). In the second

experiment, the independent variables were verb type (directional motion versus motion) and type of prepositional phrase (directional versus non-directional). The dependent variable in all conditions was processing time (in milliseconds) and response accuracy (as measured by two methods: i.e., the number of correct words in the correct order and and error score. Analyses of variance (ANOVA) were utilized to determine the statistical significance of each of the independent variables.

CHAPTER 3

RESULTS

Two experiments were conducted to evaluate the influence of verb class and complexity of predicate structure on sentence processing. Contrasts between verb types (directional motion, motion and non-motion verbs) and type of prepositional phrases (implied versus non-implied preposition and directional versus non-directional phrases) were investigated. Sixty-four subjects were assigned to one of two experiments and one of two stimulus presentation procedures (RSVP or SPR). Responses consisted of reaction time to the entire sentence (RSVP) or to individual word presentations (SPR) and two measures of response accuracy --the number of correct words in the correct order (Accuracy 1) and an error type analysis (Accuracy 2).

Two separate analyses of variance (ANOVA) were computed using the Statistical Analysis System for the Personal Computer (SAS-PC) (Joyner, 1985; Allen and Kalt, 1985). The analysis for Experiment 1 was a two-way ANOVA analyzing verb type and task. For Experiment 2, a three-way ANOVA was completed testing the influence of verb type, prepositional phrase type and task.

Preliminary Analyses

Two preliminary procedures were undertaken to prepare subject responses for statistical analyses. These included possible data normalization and data set generation. A brief discussion follows.

Assessment of the Need to Normalize the Data

A series of Pearson product moment correlation coefficients were run to determine the need for data normalization. It was believed that the scores gathered from the reading screening test (i.e., reading speed and level) could be used to minimize the inter-subject reading skill differences. Reading speed and level were determined to be in moderately weak correlation ($r < 0.34$) with the reaction time and accuracy data for both tasks and experiments. Since the majority of the correlations were less than 0.20, response normalization with the reading scores would not appreciably affect the current data. Furthermore, the standard deviations of the group responses did not indicate a significant need to normalize the data set. The means and standard deviations of all dependent variables are listed in Appendix D.

Generation of the Data Sets

One-way analyses of variance (ANOVAs) were run to determine if the subjects performed differently on the nonsense sentences when compared to the stimulus items. The results were supportive of this idea in that all reaction time data (except one contrast--score 1 on SPR in Experiment 2--which was non-significant) indicated longer response latencies for the nonsense material. In addition, more missing words and errors were noted for this category in Accuracy 1 and 2 scores. Since they were included as a control measure and their scores were of little consequence to the current experimental design, the nonsense sentences were taken out of the data set. Only the sentences corresponding to the desired verb and preposition type differences were left. The responses were then sorted into Experiments 1 and 2. This procedure resulted in a total number of 1920 entries in Experiment 1 and 2560 in Experiment 2.

Discussion of the Statistical Findings

Results of the Analysis of Variance for Experiment 1

The first experimental design analyzed the effects of verb type and task by the subjects. There were three kinds

of verbs tested motion, directional motion and non-motion verbs. The task variable consisted of two levels RSVP and SPR. In order to compare performance on the two stimulus presentation techniques, this investigator had to decide which of the nine scores produced by the SPR procedure would be the best test of a verb difference. Two different scores were generated for this purpose. The first reflected the reaction time associated with the verb position (which varied between the sentences) and the second was a mean of the nine individual word scores. As it turned out, there was no difference in the overall results when either score was utilized, so the verb position data will be presented. The mean sentence score data can be found in Appendix D.

Verb type and task effects were first analyzed with respect to response latency. As illustrated in Figure 1, scores varied between the two stimulus presentation procedures, yet the verb means were very similar. Hence, performance in the SPR condition was faster than RSVP and verb type did not elicit different processing behavior from the subjects. These findings were verified with an ANOVA. As Table 1 illustrates, only the main effect of task was significant (F value = 34.80; $df = 1,1914$; $p < 0.0001$). Post hoc testing was conducted with the Bonferroni procedures because it is a powerful test for differences between group means while controlling the error rate per

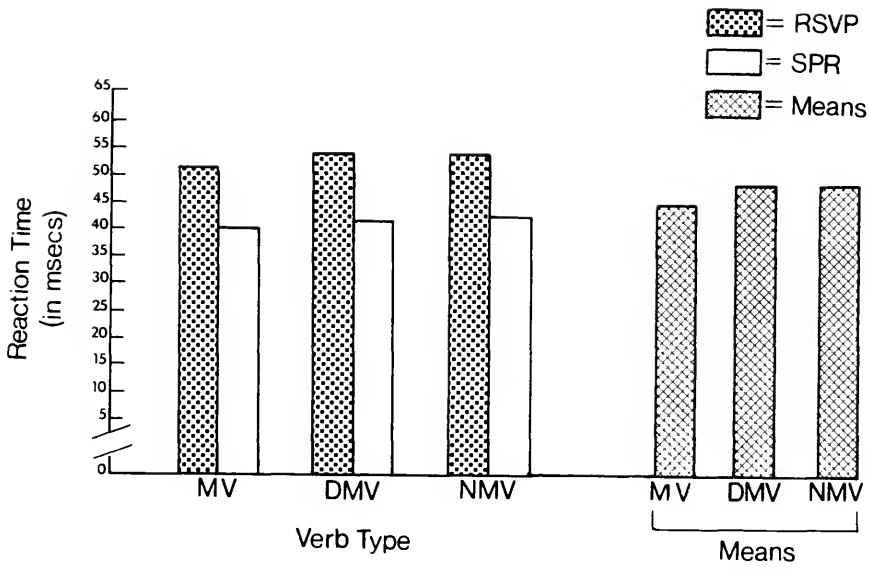


Figure 1. Profile of the Reaction Time Means for Verb Types by Task and Overall Verb Type Means in Experiment 1. The Verb Types are Identified as Follows: MV = Motion Verb, DMV = Directional Motion Verb and NMV = Non-Motion Verb.

Table 1

Summary Table of the Two Factor Analysis of Variance Between Verb Type and Task as reflected by Reaction Time

Source	df	Sums of Squares	Mean Square	F value	p
Verb	2,1914	0.0931	0.0465	0.31	0.7361
Task	1,1914	5.2872	5.2872	34.80	0.0001**
Verb*Task	2,1914	0.1025	0.0512	0.34	0.7137

** Significant at the 0.05 level

Analysis of the Differences for the Main Effect of Task Utilizing the Bonferroni Procedures.

		RSVP	SPR
	Means	0.5666	0.4616
RSVP	0.5666		0.1050**
SPR	0.4616		

MSE = 0.1519, n = 640, df = 1914, Min. Sig. Diff. = 0.0522
** Significant at the 0.05 level (Critical Value = 2.3961)

family and allowing an unequal N between cells (Agresti and Agresti, 1979; Joyner, 1985). These results indicated that the RSVP response time was longer than SPR (see Table 1).

While the results of the ANOVA analyzing reaction time did not demonstrate a difference related to verb type, Accuracy 1 did. Figure 2 displays these verb and task differences. There is a notable discrepancy between verb type performances. Motion verbs appear to be processed more easily than other verb types. The difference between directional motion and non-motion verb means seems to be negligible. Statistical analysis (see Table 2) revealed that the main effects of task and verb type were significant. The two-way interaction was non-significant. These results suggest that there is a difference between verb types that was not dependent upon the task. Post hoc testing with the Bonferroni procedures (see Table 3) indicated that subjects remembered fewer correct words in the correct order when the target sentence contained a directional motion as opposed to motion verb. There was no difference between the other verbs. In addition, response accuracy was also greater in the SPR condition.

The error severity means (Accuracy 2) revealed a pattern similar to that of Accuracy 1. This is pictured in Figure 3. However, the ANOVA listed in Table 4 reveals no significant main effects or interaction. Nevertheless, both main effects are approaching significance.

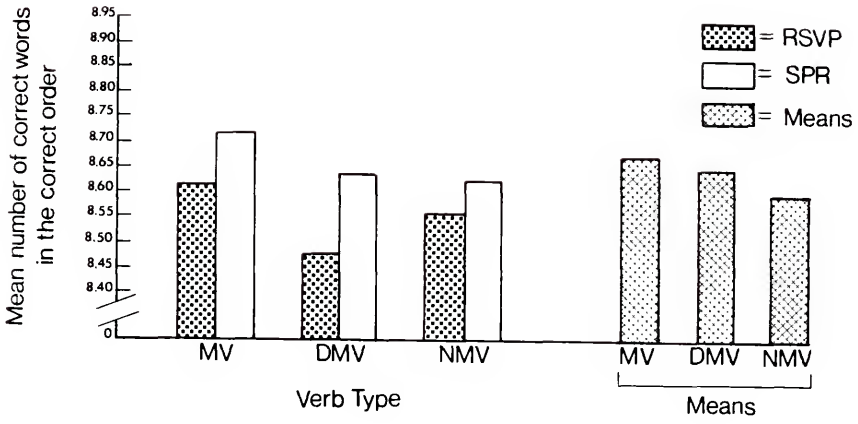


Figure 2. Profile of the Accuracy 1 Means for Verb Types by Task and Overall Verb Type Means in Experiment 1. The Verb Types are Identified as Follows: MV = Motion Verb, DMV = Directional Motion Verb and NMV = Non-Motion Verb.

Table 2

Summary Table of the Two Factor Analysis of Variance Between Verb Type and Task as reflected by Accuracy 1

Source	df	Sums of Squares	Mean Square	F value	p
Verb	2,1895	4.9719	2.4859	3.35	0.0352**
Task	1,1895	6.4340	6.4340	8.68	0.0033**
Verb*Task	2,1895	0.9269	0.4635	0.62	0.5354

** Significant at the 0.05 level

Table 3

Analysis of the Differences for the Main Effects of Verb and Task in Accuracy 1 Utilizing the Bonferroni Procedures.

		Motion Verbs	DMV	Non-motion Verbs
	Means	8.6746	8.5510	8.5946
Motion Verbs	8.6746		0.1236**	0.0800
DMV	8.5510			-0.0436

MSE = 0.7416, n = 630-637, df = 1895, Min. Sig. Diff. = 0.1167
** Significant at the 0.05 level (Critical Value = 2.3961)

		RSVP	SPR
	Means	8.5491	8.6649
RSVP	8.5491		0.1158**
SPR	8.6649		

MSE = 0.7416, n = 630-637, df = 1895, Min. Sig. Diff. = 0.0955
** Significant at the 0.05 level (Critical Value = 1.9612)

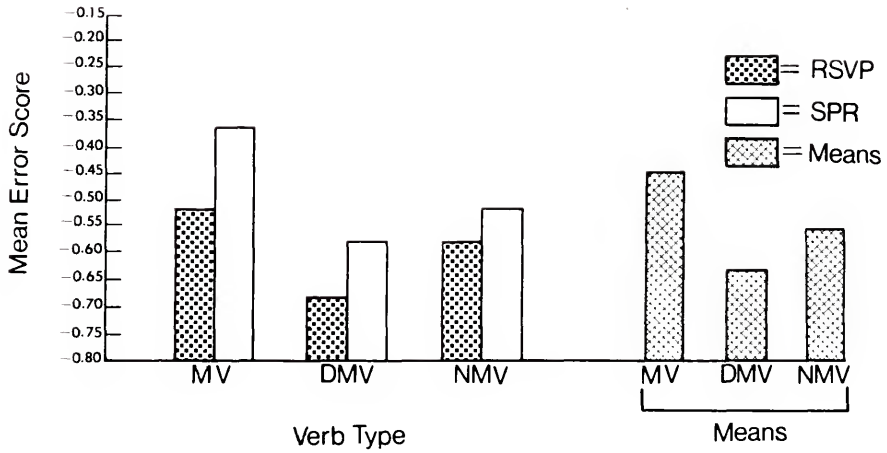


Figure 3. Profile of the Accuracy 2 Means for Verb Types by Task and Overall Verb Type Means in Experiment 1. The Verb Types are Identified as Follows: MV = Motion Verb, DMV = Directional Motion Verb and NMV = Non-Motion Verb.

Table 4

Summary Table of the Two Factor Analysis of Variance Between Verb Type and Task as reflected by Accuracy 2

Source	df	Sums of Squares	Mean Square	F value	p
Verb	2,1895	11.9729	5.9865	2.88	0.0561
Task	1,1895	6.5616	6.5616	3.16	0.0756
Verb*Task	2,1895	0.7365	0.3683	0.18	0.8374

** Significant at the 0.05 level

Results of the Analysis of Variance for Experiment 2

Task, verb type and prepositional phrase type were assessed in the second experimental design. Once again, task included RSVP and SPR and verb type consisted of directional motion and motion verbs. Prepositional phrase type had four levels which paired implied and non-implied prepositions (and in the case of motion verbs, two non-implied prepositions) with directional and non-directional phrases. Three factor analyses of variance were run for each of the following dependent variables: reaction time, Accuracy 1 and 2. As discussed earlier, the selection of which response latency score to use from the SPR data was considered. The three-way ANOVA was run with each of the following acting as the reaction time of interest: verb score, preposition score, object of the preposition score and a mean of all nine scores. Since the results were basically the same for all four measures, the experimenter decided to use the mean of all nine scores as it seemed to include the information tapped into by the other three scores. Appendix D includes the summary tables for these other analyses.

Since a three factor ANOVA was run in the second experiment, the interactions will be discussed before focusing on the simple effects. The reaction time data, presented in Table 5, demonstrates that the three-way

interaction was not significant, but that two of the two-way interactions (verb type--prepositional type and task--verb type) were significant. Hence, prepositional phrase type differences were dependent upon specific verb and task categories. So, this analysis was then rerun controlling task and verb type. Table 5 reveals that only prepositional phrases with directional motion verbs in the RSVP condition were significantly different (F value = 8.43, $df = 3,2544$, $p < 0.05$). Figure 4 displays the graphs of the four means in this condition. The non-implied preposition in a non-directional phrase was responded to most quickly, while use of the implied preposition with a non-directional phrase was the slowest. These findings were verified using the Bonferroni procedures. As Table 6 indicates, use of the implied preposition in a non-directional sense was the most difficult to understand. No significant differences were noted between the other prepositional phrase types.

The scores for Accuracy 1 were also analyzed with a three-way ANOVA and the results are listed in Table 7. As indicated in this table, the three-way interaction between task, verb type and prepositional phrase type was not significant and only the two-way interaction between verb and prepositional phrase type was significant (F value = 6.64, $df = 3, 2532$, $p < 0.0002$). Once again, the effect

Table 5

Summary Table of the Three Factor Analysis of Variance Between Task, Verb and Prepositional Phrase as reflected by Reaction Time

Source	df	Sums of Squares	Mean Square	F value	p
Task*Verb*Prep	3,2544	1.6988	0.5663	2.57	0.0527
Verb*Prep	3,2544	1.8410	0.6137	2.78	0.0395**
Task*Prep	3,2544	0.8771	0.2924	1.33	0.2639
Task*Verb	1,2544	1.1523	1.1523	5.23	0.0223**
Task = RSVP, Verb = DMV					
Prep	3,2544	5.5761	1.8587	8.43	**
Task = RSVP, Verb = MV					
Prep	3,2544	0.4443	0.1481	0.67	
Task = SPR, Verb = DMV					
Prep	3,2544	0.0547	0.0182	0.08	
Task = SPR, Verb = MV					
Prep	3,2544	0.0633	0.0211	0.10	

** Significant at the 0.05 level

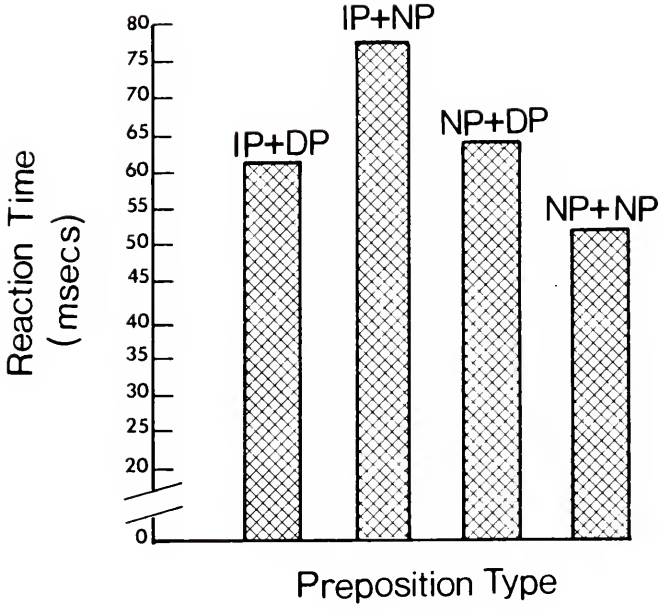


Figure 4. Profile of the Reaction Time Means in the RSVP--Directional Motion Verb Category of Experiment 2. The Prepositional Phrase Types are
IP+DP = Implied Prep. and Directional Phrase
IP+NP = Implied Prep. and Non-Directional Phrase
NP+DP = Non-Implied Prep. and Directional Phrase
NP+NP = Non-Implied Prep. and Non-Directional Phrase.

Table 6

Analysis of the Differences Between Simple Effects Relating to Prepositional Phrase Type for Reaction Time Utilizing the Bonferroni Procedures.

RSVP and Directional Motion Verbs

		IP+NP	NP+DP	NP+NP
	Means	0.7760	0.6357	0.5143
IP+DP	0.6149	-0.1611**	-0.0208	0.1006
IP+NP	0.7760		0.1403**	0.2617**
NP+DP	0.6357			0.1214

MSE = 0.2261, n = 160, df = 2544, Min. Sig. Diff. = 0.1403
** Significant at the 0.05 level (Critical Value = 2.64)

Table 7

Summary Table of the Three Factor Analysis of Variance Between Task, Verb and Prepositional Phrase as reflected by Accuracy 1

Source	df	Sums of Squares	Mean Square	F value	p
Task*Verb*Prep	3,2532	1.5082	0.5027	0.56	0.6404
Verb*Prep	3,2532	17.8265	5.9422	6.64	0.0002**
Task*Prep	3,2532	5.4670	1.8223	2.04	0.1068
Task*Verb	1,2532	0.5187	0.5187	0.58	0.4466
Task = RSVP, Verb = DMV					
Prep	3,2532	9.0853	3.0284	3.38	**
Task = RSVP, Verb = MV					
Prep	3,2532	1.6295	0.5432	0.61	
Task = SPR, Verb = DMV					
Prep	3,2532	7.4671	2.4890	2.78	**
Task = SPR, Verb = MV					
Prep	3,2532	11.7674	3.9225	4.38	**

** Significant at the 0.05 level

the ANOVA was rerun controlling for task and verb type; however, the results were different from that of the reaction time data. Prepositional phrase type was significantly different in three of the four task and verb type pairings (see Table 7). The means for these data are presented in Figures 5, 6 and 7.

Figures 5 and 6 display the following trend; the implied preposition in a directional phrase was the most accurate while the non-implied preposition with a directional phrase was the least. In fact, the latter phrase type appeared to be most different from the others, expecially in the SPR condition. The third significant phrase type difference was that of motion verbs in the SPR condition (see Figure 7). These results suggest that there is something unique about the first phrase type that is not identified by this experiment, since no differences were expected between the motion verb contrasts.

Bonferroni procedures were utilized to determine which prepositional phrase types deviated from the others; Table 8 displays these results. Directional motion verbs produced a preposition difference in both tasks. With RSVP, the non-implied preposition used in a directional sense was less accurate than the implied preposition in a directional phrase. All other pairings were non-significant. While no pairwise comparison in the SPR

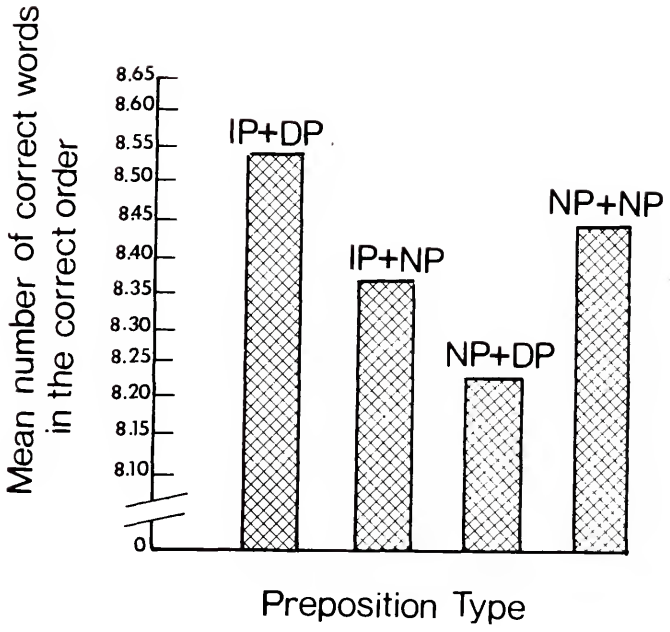


Figure 5. Profile of the Accuracy 1 Means in the RSVP--Directional Motion Verb Category of Experiment 2. The Prepositional Phrase Types are
IP+DP = Implied Prep. and Directional Phrase
IP+NP = Implied Prep. and Non-Directional Phrase
NP+DP = Non-Implied Prep. and Directional Phrase
NP+NP = Non-Implied Prep. and Non-Directional Phrase.

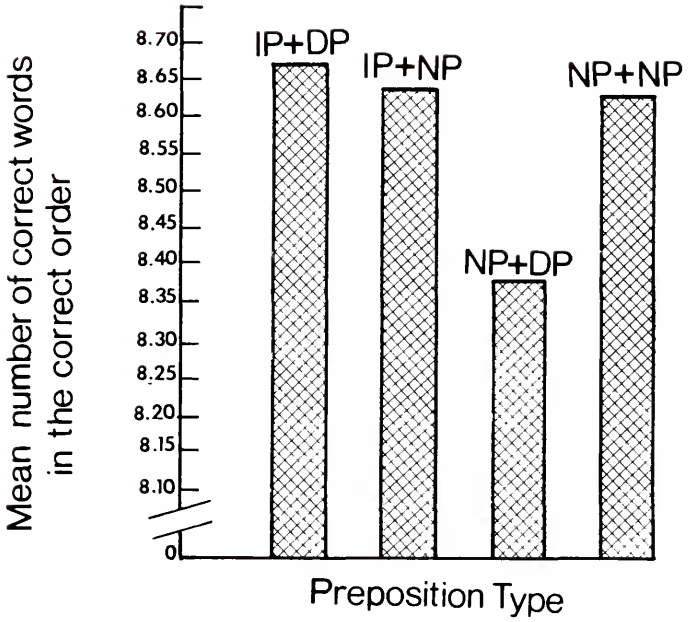


Figure 6. Profile of the Accuracy 1 Means in the SPR--Directional Motion Verb Category of Experiment 2. The Prepositional Phrase Types are
IP+DP = Implied Prep. and Directional Phrase
IP+NP = Implied Prep. and Non-Directional Phrase
NP+DP = Non-Implied Prep. and Directional Phrase
NP+NP = Non-Implied Prep. and Non- Directional Phrase.

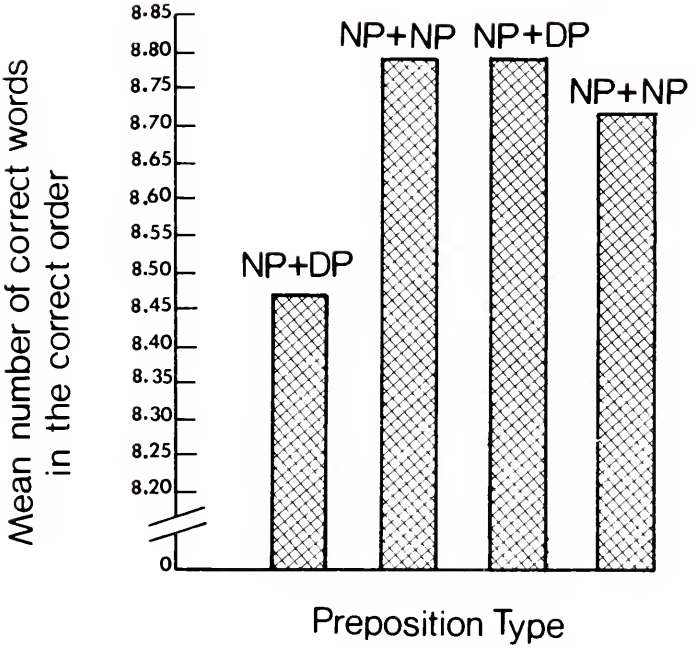


Figure 7. Profile of the Accuracy 1 Means in the SPR--Motion Verb Category of Experiment 2. The Prepositional Phrase Types are
NP+DP = Non-Implied Prep. and Directional Phrase
NP+NP = Non-Implied Prep. and Non-Directional Phrase.

Table 8

Analysis of the Differences Between Simple Effects Relating to Prepositional Phrase Type in Accuracy 1 Utilizing the Bonferroni Procedures.

Accuracy 1: Simple Effect = Preposition

RSVP and Directional Motion Verbs

		IP+NP	NP+DP	NP+NP
	Means	8.3648	8.2125	8.4438
IP+DP	8.5375	0.1727	0.3250**	0.0937
IP+NP	8.3548		0.1523	-0.0790
NP+DP	8.2125			-0.2313

SPR and Directional Motion Verbs

		IP+NP	NP+DP	NP+NP
	Means	8.6375	8.3824	8.6226
IP+DP	8.6625	0.0250	0.2701	0.0399
IP+NP	8.6375		0.2451	0.0149
NP+DP	8.3824			-0.2302

SPR and Motion Verbs

		NP+NP	NP+DP	NP+NP
	Means	8.7938	8.7862	8.7152
NP+DP	8.4591	-0.3347**	-0.3271**	-0.2561
NP+NP	8.7938		0.0076	0.0786
NP+DP	8.7862			0.0710

MSE = 0.8952 n = 316,320, df = 2532, Min. Sig. Diff. = 0.2826
** Significant at the 0.05 level (Critical Value = 2.64)

and directional motion verb category reached the minimal difference level, a significant F value in Table 7 suggested that at least one of these contrasts was important. The results from the SPR--directional motion verb condition, as listed in Table 8, mirrored those of RSVP and suggested that the non-implied preposition in the directional phrase is more difficult. Finally, Table 8 also shows that several contrasts were distinctive when motion verbs were presented with SPR procedures. For instance, one of the non-implied prepositions used in a directional sense was more difficult than the other directional phrase and one of the non-directional phrases. The final non-directional phrase also approached significance. As stated earlier, these findings were not anticipated.

Like Accuracy 1, the results of the three-way ANOVA (see Table 9) for Accuracy 2 revealed no significant interactions other than the two-way ANOVA analyzing verb and prepositional phrase type (F value = 7.29, df = 3,2532, $p < 0.0001$). Once again, the significance of prepositional phrase type was dependent upon the verb. When the ANOVA was rerun controlling for task and verb type, only two of the four conditions reached significance (see Table 9). The prepositional phrase type means for directional motion verbs suggested that the implied preposition in the directional sense was the most accurately recalled and the

non-implied preposition in the directional sense was the least (see Figure 8). Furthermore, subject performance in this latter category differed greatly from the others. When considering the SPR pairwise comparisons, Figure 9 illustrates that one of the non-implied prepositions in the directional sense was more difficult to comprehend. Responses for this category should have been similar to its sister classification (i.e., the third column from the left). The other two NP + NP groups were more alike. As stated before, these findings are suggestive of a difference between prepositional phrases that was not recognized in the development of the stimulus items.

The preceding observations are supported by the Bonferroni findings listed in Table 10. To be specific, the RSVP and directional motion verb condition indicated that the non-implied preposition used in the directional sense was the most difficult to understand. This contrast was statistically important for all prepositional phrase types other than the non-implied preposition in a non-directional phrase, which approached significance. In like fashion, Table 10 reveals that only one pairwise comparison in the motion verb--SPR condition was significant. Again, this finding is not easily explained.

Table 9

Summary Table of the Three Factor Analysis of Variance Between Task, Verb and Prepositional Phrase as reflected by Accuracy 2

Source	df	Sums of Squares	Mean Square	F value	p
Task*Verb*Prep	3,2532	4.4418	1.4806	0.59	0.6204
Verb*Prep	3,2532	54.7461	18.2487	7.29	0.0001**
Task*Prep	3,2532	12.1258	4.0419	1.62	0.1837
Task*Verb	1,2532	4.0437	4.0437	1.62	0.2037
Task = RSVP, Verb = DMV					
Prep	3,2532	42.4468	14.1489	5.65	**
Task = RSVP, Verb = MV					
Prep	3,2532	0.8809	0.2936	0.12	
Task = SPR, Verb = DMV					
Prep	3,2532	11.5701	3.8567	1.54	
Task = SPR, Verb = MV					
Prep	3,2532	23.3138	7.7713	3.12	**

** Significant at the 0.05 level

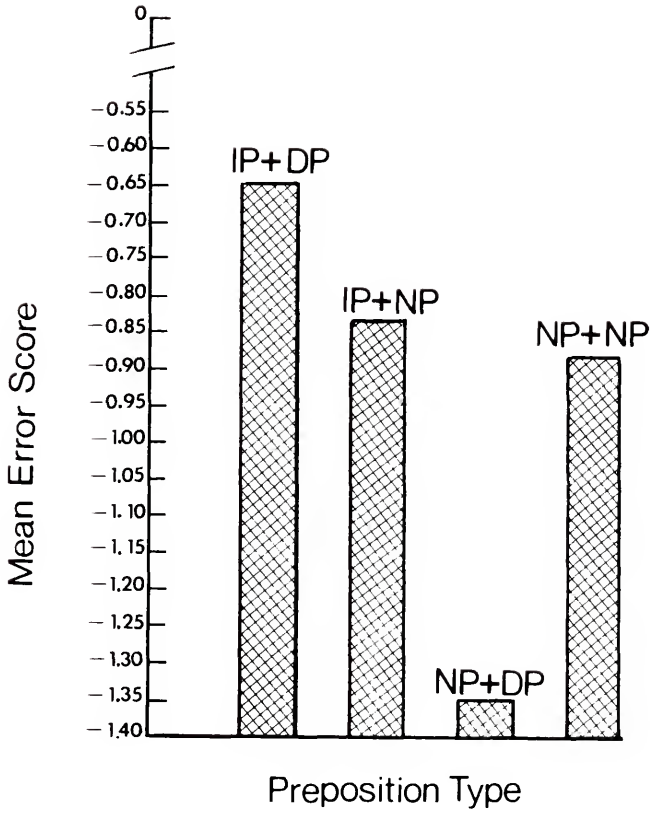


Figure 8. Profile of the Accuracy 2 Means in the RSVP--Directional Motion Verb Category of Experiment 2. The Prepositional Phrase Types are
IP+DP = Implied Prep. and Directional Phrase
IP+NP = Implied Prep. and Non-Directional Phrase
NP+DP = Non-Implied Prep. and Directional Phrase
NP+NP = Non-Implied Prep. and Non-Directional Phrase.

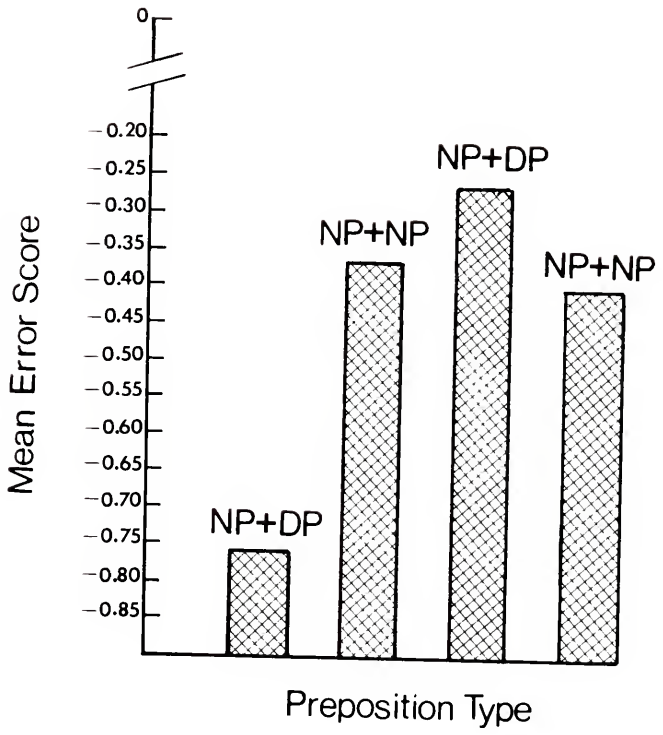


Figure 9. Profile of the Accuracy 2 Means in the SPR--Motion Verb Category of Experiment 2. The Prepositional Phrase Types are
NP+DP = Non-Implied Prep. and Directional Phrase
NP+NP = Non-Implied Prep. and Non-Directional Phrase.

Table 10

Analysis of the Differences Between Simple Effects Relating to Prepositional Phrase Type in Accuracy 2 Utilizing the Bonferroni Procedures.

RSVP and Directional Motion Verbs

		IP+NP	NP+DP	NP+NP
	Means	0.8365	1.3500	0.8875
IP+DP	0.6500	-0.1865	-0.7000**	-0.2375
IP+NP	0.8365		-0.5135**	-0.0510
NP+DP	1.3500			0.4625

SPR and Motion Verbs

		NP+NP	NP+DP	NP+NP
	Means	0.3625	0.2704	0.4051
NP+DP	0.7736	0.4111	0.5032**	0.3685
NP+NP	0.3625		0.0921	-0.0426
NP+DP	0.2704			-0.1347

MSE = 2.5021, n = 316,320, df = 2532, Min. Sig. Diff. = 0.4669
** Significant at the 0.05 level (Critical Value = 2.64)

The Influence of Verb Type in Experiment 2

The influence of verb type on the processing of prepositional phrases is depicted for reaction time and accuracy scores in Figures 10, 11 and 12. Each figure graphs eight means associated with verb and prepositional phrase type pairs (referred to as sentence type) and two means reflecting verb type. Response latency data from the RSVP condition are presented in Figure 10. There were no significant differences with SPR, so those means will not be discussed here. The means in Figure 10 demonstrate that directional motion verbs were more difficult to process than motion verbs. Consideration of the sentence type means suggested that this significant difference may only be related to one prepositional category (i.e., the implied preposition in a non-directional phrase), which was consistent with the previously discussed findings. The accuracy means for verb type displayed in Figures 11 and 12 follow the same pattern as the reaction time scores. Again, sentences with directional motion verbs were recalled less accurately. However, unlike the response latency data, the sentence type means were more variable within verb types yet maintaining a significant difference between verb categories. In summary, performance on all

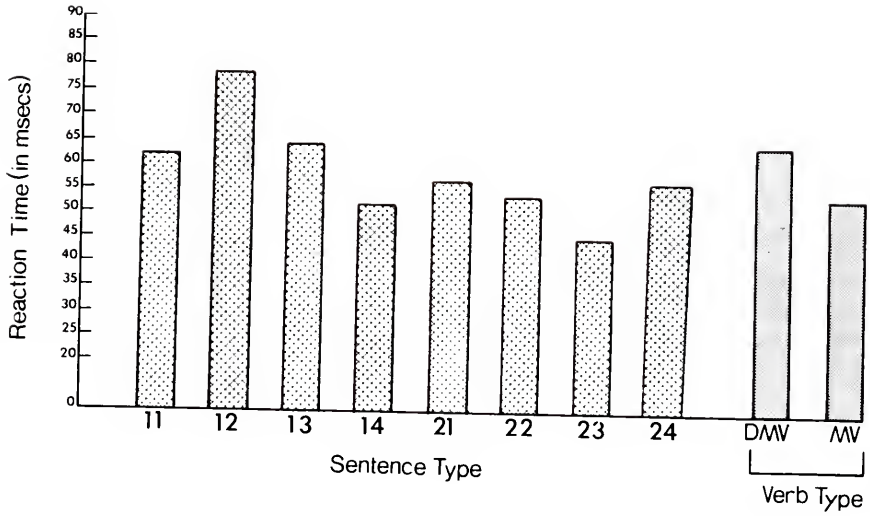


Figure 10. Profile of the RSVP Means for Sentence Type and Verb Type in Experiment 2. The Sentence Types are Identified as Follows--Implied (IP) versus Non-implied (NP) Preposition and Directional (DP) versus Non-directional Phrases (NP):

11 = DMV + IP + DP	21 = MV + NP + DP
12 = DMV + IP + NP	22 = MV + NP + NP
13 = DMV + NP + DP	23 = MV + NP + DP
14 = DMV + NP + NP	24 = MV + NP + NP.

Verb Types Include Directional Motion Verbs (DMV) and Motion Verbs (MV).

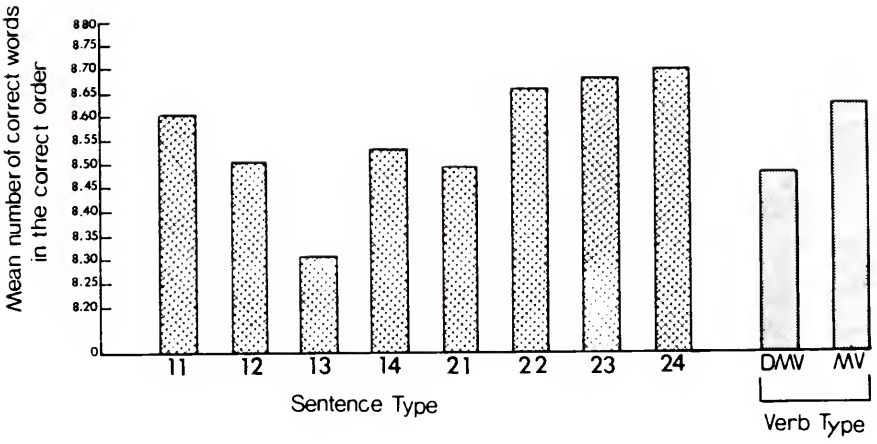


Figure 11. Profile of the Accuracy 1 Means for Sentence Type and Verb Type in Experiment 2. The Sentence Types are Identified as Follows--Implied (IP) versus Non-implied (NP) Preposition and Directional (DP) versus Non-directional Phrases (NP):

11 = DMV + IP + DP	21 = MV + NP + DP
12 = DMV + IP + NP	22 = MV + NP + NP
13 = DMV + NP + DP	23 = MV + NP + DP
14 = DMV + NP + NP	24 = MV + NP + NP.

Verb Types Include Directional Motion Verbs (DMV) and Motion Verbs (MV).

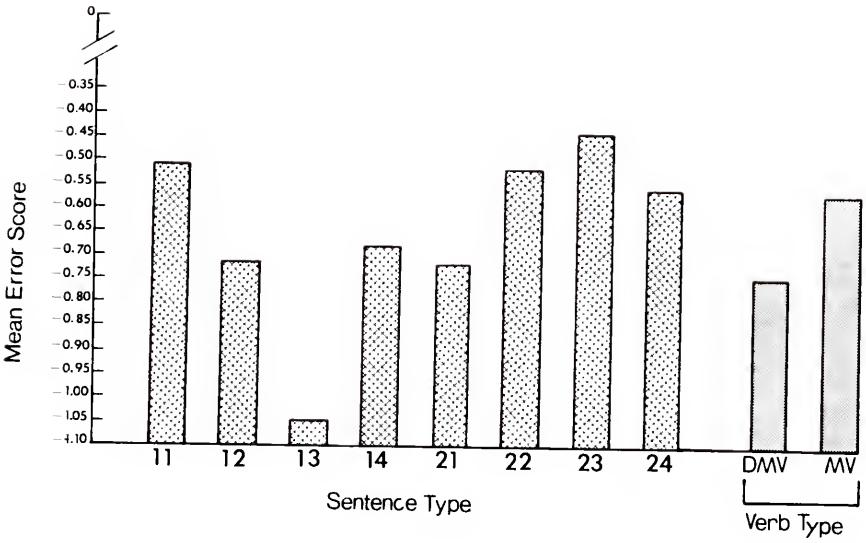


Figure 12. Profile of the Accuracy 2 Means for Sentence Type and Verb Type in Experiment 2. The Sentence Types are Identified as Follows--Implied (IP) versus Non-implied (NP) Preposition and Directional (DP) versus Non-directional Phrases (NP):

11 = DMV + IP + DP	21 = MV + NP + DP
12 = DMV + IP + NP	22 = MV + NP + NP
13 = DMV + NP + DP	23 = MV + NP + DP
14 = DMV + NP + NP	24 = MV + NP + NP.

Verb Types Include Directional Motion Verbs (DMV) and Motion Verbs (MV).

dependent variables supported the premise that directional motion verbs were harder to understand than motion verbs.

Since prepositional phrase type differences have been specified in the preceding discussion, only the verb type results will be mentioned here. The two factor ANOVA presented in Table 11 illustrates that the two-way interaction between verb type and task was significant (F value = 5.20; df = 1,2556; $p < 0.0227$). When the task variable was controlled and the ANOVA rerun, verb differences were only evidenced in the RSVP condition. Testing of the simple effects with the Bonferroni procedures (see Table 11) indicated that directional motion verbs had slower response times than motion verbs. As such, the latter are believed to be easier to process.

The accuracy findings did not reveal a signficant two-way interaction between verb type and task; however both main effects were significant (see Tables 12 and 13). Simple effects were calculated with the Bonferroni procedures. As reported in Tables 12 and 13, sentences with motion verbs had more words recalled in the correct order and error severity scores of lesser magnitude. Again, motion verbs were found to be easier to comprehend than directional motion.

Table 11

Summary Table of the Two Factor Analysis of Variance Between Verb Type and Task as reflected by Reaction Time

Source	df	Sums of Squares	Mean Square	F value	p
Verb	1,2556	1.6332	1.6332	7.36	0.0067
Task	1,2556	0.8640	0.8640	3.90	0.0485
Verb*Task	1,2556	1.1523	1.1523	5.20	0.0227**
Task = RSVP					
Verb	1,1278	2.7646	2.7646	7.27	0.0071**
Task = SPR					
Verb	1,1278	0.0209	0.0209	0.33	0.5657

** Significant at the 0.05 level

Analysis of the Differences for the Simple Effects of Verb Type in RSVP Utilizing the Bonferroni Procedures.

		DMV	MV
	Means	0.6352	0.5423
DMV	0.6352		0.0929**
MV	0.5423		

MSE = 0.2218, n = 640, df = 2556, Min. Sig. Diff. = 0.0599
** Significant at the 0.05 level (Critical Value = 2.2735)

Table 12

Summary Table of the Two Factor Analysis of Variance Between Verb Type and Task as reflected by Accuracy 1

Source	df	Sums of Squares	Mean Square	F value	p
Verb	1,2544	12.1643	12.1643	13.48	0.0002**
Task	1,2544	16.5105	16.5105	18.29	0.0001**
Verb*Task	1,2544	0.5271	0.5271	0.58	0.4449

** Significant at the 0.05 level

Analysis of the Differences for the Main Effect of Verb Type Utilizing the Bonferroni Procedures.

		DMV	MV
	Means	8.4843	8.6226
DMV	8.4843		-0.1383**
MV	8.6226		

MSE = 0.9027, n = 1276,1272, df = 2544, M.S.Diff. = 0.0856
** Significant at the 0.05 level (Critical Value = 2.2735)

Table 13

Summary Table of the Two Factor Analysis of Variance Between Verb Type and Task as reflected by Accuracy 2

Source	df	Sums of Squares	Mean Square	F value	p
Verb	1,2544	22.4369	22.4369	8.90	0.0029**
Task	1,2544	53.9306	53.9306	21.39	0.0001**
Verb*Task	1,2544	4.0773	4.0773	1.62	0.2036

** Significant at the 0.05 level

Analysis of the Differences for the Main Effect of Verb Type Utilizing the Bonferroni Procedures.

		DMV	MV
	Means	0.7461	0.5582
DMV	0.7461		0.1879**
MV	0.5582		

MSE = 2.5210, n = 1276,1272, df = 2544, M.S.Diff. = 0.1430
** Significant at the 0.05 level (Critical Value = 2.2735)

The Influence of Task in Experiment 2

Task effects were evident in all three dependent variables. For the reaction time data, RSVP proved to be the most sensitive to differences in verb and prepositional phrase type (see Table 5). SPR did not indicate any latency differences between levels of prepositional phrases. Both types of accuracy data revealed that subject performance was more accurate in the SPR condition than in RSVP (see Table 14). Likewise, significant differences between prepositional phrase contrasts were found using both tasks (see Tables 8 and 10). It was interesting to note that the motion verb differences were only found in the SPR condition.

Table 14

Analysis of the Differences for the Main Effect of Task in Accuracy 1 and 2 Utilizing the Bonferroni Procedures

Accuracy 1		RSVP	SPR
	Means	8.4629	8.6339
RSVP	8.4629		-0.1610**
SPR	8.6339		

MSE = 0.8952, n = 1275,1273, df = 2532, M.S.Diff. = 0.0856
**Significant at the 0.05 level (Critical Value = 1.9609)

Accuracy 2		RSVP	SPR
	Means	0.7976	0.5067
RSVP	0.7976		0.2910**
SPR	0.5067		

MSE = 2.5021, n = 1275,1273, df = 2532, M.S.Diff. = 0.1430
** Significant at the 0.05 level (Critical Value = 1.9609)

CHAPTER 4

DISCUSSION AND CONCLUSIONS

Past studies have highlighted the importance of cues in establishing the grammatical structure of a sentence (Fodor and Garrett, 1967; Fodor et al., 1968; Foss and Lynch, 1969; Forster, 1970; Hakes and Cairns, 1970; Hakes, 1971; Forster and Ryder, 1971; Holmes and Forster, 1972; Forster and Olbrei, 1973). Further, Just and Carpenter (1987) have stated that these cues aid syntactic analysis by indicating how to group words into constituents and showing interrelations among sentence elements. Furthermore, different types of indicators provide converging information which allow the reader to arrive at the correct interpretation of a sentence. To specify these cues, Just and Carpenter propose the following: word order, word class, function words, affixes, word meanings and punctuation. First, word order identifies role in a sentence. Second, while also inferring syntactic role, word class can describe the jobs of some of the neighboring sentential elements. Next, function words elucidate the syntactic or semantic function of a sentence item, rather than its content. However, functors provide more reliable

evidence about the segmentation of a phrase. In turn, affixes, being attached to content words, emphasize the syntactic role. Finally, word meanings are helpful in analyzing the grammatical relations among phrases and punctuation serves as another segmentation cue. It is contended that with this information, readers are able to generate an accurate appraisal of a sentence's meaning (i.e. comprehend the sentence). So, investigation of the power of some of these cues can contribute to our knowledge of the comprehension process.

Of particular interest to this investigation are the contributions of word class and function words as they relate to the action of the verb in a sentence. The need for study in this area is substantiated by several neurolinguistic studies which have emphasized the importance of such cues during comprehension. The investigators in this area have demonstrated that aphasic patients have difficulty processing the cited linguistic information, hence understanding is impaired (von Stockert, 1972; von Stockert and Bader, 1976; Zurif and Caramazza, 1976; Zurif, Green, Caramazza and Goodenough, 1976; Heeschen, 1980; Saffran, Schwartz and Marin, 1980a; Friederici, 1982, 1983; Grodzinsky and Zurif, 1984; Smith and Mimica, 1984). However, their findings have been inconsistent and other researchers have suggested that continued study in the area of verb processing may be

profitable (Saffran, Schwartz and Marin, 1980b; Jones, 1984). In fact, Saffran et al. have noted that their neurologically impaired subjects have trouble with verbs that encode a relationship between two sentence items as opposed to revealing something about the actor (i.e., the performer related to the verb). These investigators also pointed out that it is these verbs that dictate word order in a sentence (via word class information).

Jones (1984) carried out an extensive study of verb processing in an aphasic population. He demonstrated a processing difference which he attributed to lexical semantic classifications of three verb types: directional motion, motion and non-motion verbs. His premise was that the preposition implied in the use of the directional motion verb increased the processing complexity of the sentence; an idea also supported by Saffran et al., (1980b) who utilized the terms, inherent versus relational verb forms. The former implies an action that occurs within the subject while relational verb forms indicate a relationship between two nouns. The meaning of this second type of sentence rides on the ability of the reader to decode the interaction between the other sentential elements. While these results are important, they were obtained utilizing language data from brain-damaged (i.e., aphasic) individuals. As such, more basic studies using

normal language users should be completed before any hypotheses about the relative importance of certain cue types can be structured.

The current investigations were devised to test the assumptions postulated by Jones (1984) but with a group of normal college-age subjects. To be specific, these experiments were carried out to probe the influence of word class and function word cues during reading. Cue type was examined by selecting verb and prepositional phrase types as they act to influence comprehension. Techniques commonly used in psycholinguistic experiments of sentence processing, rapid serial visual presentation (RSVP) and subject paced reading (SPR) procedures, were chosen for stimulus presentation. These techniques allow investigators to monitor the reading performance of subjects by providing response latency information corresponding to comprehension difficulty. Two methods were used because each provides different cognitive information; RSVP signals an overall measure of processing and SPR taps into the amount of time spent on each word. Hence, it was expected that the reaction time data provided by these two procedures would indicate whether the processing load associated with comprehension of the individual verb or preposition types is observed at the end of the sentence or during reading (i.e., on-line). In addition, two measures of response accuracy--the number

of correct words in the correct order and an error type analysis were included as further tests of understanding. It is possible that sentential complexity would not be present in response latency but could be noted in how well the sentence is remembered. Furthermore, past research has indicated that understanding is not an unitary phenomenon that is only tested with one procedure (Hakes and Cairns, 1970). Hence, the measurement of subject comprehension would be enhanced by studying both processing time and sentence recall.

The present studies were devised to individually assess the cues provided by verb type and then the influence of prepositional phrase type on verb processing. Experiment 1 evaluated comprehension with respect to three lexical semantic verb categories. The second experiment built upon the first by determining the role of functor information and verb type during reading. As stated, sentential complexity was analyzed utilizing two methods of stimulus presentation and two techniques of response scoring. Research questions analyzed the effects of verb and prepositional phrase type as well as differences between comprehension measures.

Discussion of the Findings in Experiment 1

The first experiment was designed to assess the processing difference between three lexical semantic verb categories. These verb types included directional motion, motion and non-motion verbs. Stimuli were written so that each sentence frame was presented three times, once with each verb class. This control was employed in order to permit localization of any sentential complexity effects associated with the verb alone and to minimize the influence of other linguistic factors. Finally, when the results were examined as a function of the forms of comprehension testing, it was found that only one of the accuracy measures revealed a processing difference--the one between the directional motion and motion verbs. No significant variations occurred between the non-motion and other verb types. Of minor interest was the discrepancy noted in both the response latency and accuracy data with respect to task. Specifically, SPR performance was consistently faster and more exact than RSVP data.

Verb Type Effect

The above results appear to indicate that directional motion verbs are more complex than motion verbs, but this effect is dependent upon how "understanding" is measured.

In addition, this outcome cannot be solely attributed to the embedded predicate, associated with the directional motion verb (Jones, 1984), because non-motion verbs did not behave significantly different from other verb forms. Hence, motion verbs are easier to process than directional motion verbs, but no more difficult than non-motion. On the other hand, directional motion are understood as easily as non-motion verbs. Nevertheless, this verb type effect was only found for one of the accuracy measures and therefore should be carefully considered.

As has been stated, several different methods of comprehension testing were used to illustrate the nature of the relationship between verb types. Since past research had shown that no technique was the most reliable measure of cognitive processing (Fodor et al., 1968; Hakes, 1971), the sensitivity of the tests utilized had to be considered. Negative conclusions (i.e., lack of processing differences) may mean that the test of understanding was not sensitive enough to identify a difference. In other words, the measure may not be difficult enough to induce the desired behavior in normal individuals. On the other hand, the absence of an effect may indicate that a connection between the independent and dependent variables does not exist. Finally, if all scores are in agreement, then one could say something about the strength of the conclusions.

The present results do not demonstrate a consistent verb effect across scoring procedures. In fact, only the Accuracy 1 results reveal a variation in verb processing. Since Accuracy 1 represents the number of correct words recalled in the correct order, these findings suggest that sentences with directional motion verbs are more difficult to recall than those with motion verbs. Furthermore, the same trend was noted in the Accuracy 2 (error analysis) findings; however, the results there only approached significance. Hence, it can be concluded that the severity of the errors noted between verb types did not significantly differ. Directional motion verbs only proved to be slightly more complex. These effects suggest that the accuracy measures used were sensitive enough to permit detection of a significant difference between two of the verb types. Nevertheless, the strength of the noted effect is in question as it did not consistently appear in all measures of comprehension testing (i.e., response latency).

The reaction time data for both the SPR and RSVP conditions did not show a difference between verb types. In fact, the scores within each presentation mode were practically identical. Hence, the subjects did not respond differentially to the sentences. These findings also could be related to the use of identical sentence frames for the verb types. While this control did highlight the influence of the verb, it may have confounded the desired effect in

sentence processing by increasing the participant's familiarity with the test phrases. Even so, the present results suggest that the recall data was more sensitive to processing complexity than response latency, even during on-line processing.

Experiment 1 Results Compared with Other Similar Studies

Since this project evaluated several of Jones's (1984) claims, the discussion will begin with his views. The present results support Jones, at least to some extent, because directional motion verbs were found to be more difficult to process than motion verbs. However, his results also showed that non-motion verbs behaved like motion verbs and no such effect was evidenced in this experiment. Using his finding, he defended the notion that the embedded predicate associated with the directional motion verb increased its processing load. This statement is not supported with the normal data; however there could be several reasons for the discrepancies--among them are the protocol differences discussed below.

A major difference between experimental protocols was embedded in the subset of non-motion verbs utilized. The list in the current research included verbs that displayed a lack of motion (e.g. stare, forget), while Jones used action verbs that did not involve movement from one

location to another (e.g. shoots, paints). This change in non-motion verb categorization resulted in verb processing that was not significantly different from either the motion or directional motion verbs. The non-motion verbs were supposed to act as a lexical semantic control since they differed from motion verbs only in terms of type of action. Thus, it may be possible that the non-motion verbs utilized in this experiment were more complicated than Jones's stimulus items. Since this control was ineffective, Jones's hypothesis that directional motion verbs were more complex because of an implied preposition stored with the lexical entry was not supported by the present results. Furthermore, the current findings are in agreement with Mitchell and Green (1978). These investigators did not find a verb complexity effect (between transitive and complement verbs) using SPR procedures but did note "verb selectivity." The latter concept includes those verbs which predict how a sentence should end (i.e., drink versus enjoy). In other words, certain predicates linguistically specify particular objects. It would appear then that these non-motion verbs in the current study were non-selective and thereby more complex.

Another difference between the two sets of protocols was the type of stimulus item utilized. Jones used different sentence frames for his verbs. On the other hand, attempts were made in this study to control the

linguistic factors within a sentence that could contribute to a processing difference related to something other than the verb. This control, however, resulted in the creation of some sentences, that while plausible, were somewhat awkward when read (see Appendix B). Perhaps the infrequency with which the non-motion verbs occurred in sentences like those in Experiment 1 caused readers to perform differently than they did with motion verbs.

The third adaptation concerned the complexity of the task. Jones (1984) utilized a picture matching test with his aphasic patients. As noted with his normal controls, this method was too easy and did not produce a verb type effect. Therefore, stimulus presentation procedures described in the psycholinguistic literature were reviewed and the RSVP and SPR techniques were selected. This protocol change may have affected cognition because the mode of information reception had been changed. Jones analyzed auditory comprehension by pointing responses and this study measured the process of understanding while reading with response latency and accuracy measurements. Since these avenues of processing involve different brain mechanisms to activate the lexical repository, the comparison was really one of auditory-visual versus visual processing. This change not only made the technique more difficult for normals; it also analyzed another aspect of cognitive processing.

In addition to a change in stimulus presentation, the sentences themselves were constructed differently than were those presented by Jones (1984). Simple active reversible declarative sentences were utilized in the aphasic patient's task, while the current investigation used simple active irreversible declaratives. This modification was necessary because an equal number of irreversible phrases could not be generated for all verb types. As stated earlier, reversible phrases are more difficult to comprehend because the subject cannot rely on world knowledge to guide his/her interpretation. Irreversible stimulus items provide semantic cues to guide processing; hence they are easier to understand (Forster and Ryder, 1971; Forster and Olbrei, 1973). Use of this sentence type may have made the task too "easy" for normals.

Other verb complexity literature has focused on syntactic function--specifically between complement and transitive verbs. The premise was that complement verbs could take on several deep structures and accept both complements and direct objects. On the other hand, transitive verbs have one underlying phrase type and can take a direct object. When using these verb forms, Fodor et al. (1968) controlled the sentence frames in a fashion similar to this study and found no effect with an anagram task. However, with center embedded phrases and a paraphrase task, these researchers found that transitive

verbs were easier to process. Moreover, Hakes (1971) only found verb complexity effects when using paraphrase. Such results support the current project in that isolation of the verb discrepancy did not yield a processing difference in any condition other than paraphrase. Hence, processing differences in verb types are difficult to produce and seem to be most easily recognized in the subjects' recall of the stimulus item.

Summary of Experiment 1 Findings

As has been stated, the findings of the first experiment revealed that motion verbs were easier to comprehend than directional motion. However, this effect was not consistent across all measures of comprehension. Verb complexity was confirmed only in Accuracy 1; Accuracy 2 presented it as a trend. Hence, sentence recall was the most sensitive measure of understanding and this belief is supported by past research (Fodor et al., 1968; Hakes, 1971). No differences between verbs were evidenced in the response latencies. However, the lack of differences in the majority of the findings suggests that the contrast between the motion and directional motion verbs may not be very strong and not of substantial significance in terms of sentential processing.

As has been pointed out, the findings cited above support Jones (1984) except with respect to the non-motion verbs. These verbs were included only as a lexical semantic control between the directional motion and motion verbs. As such, non-motion verbs differed from the directional motion and motion verbs semantically, but should have performed like motion verbs syntactically and lexically. This lack of significance weakens Jones's claim that directional motion verbs are the most difficult to understand because they have a more complex predicate structure. Several reasons for the current findings were proposed; they include use of a different subset of non-motion verbs, control of the sentence frames, use of more difficult tasks than Jones's and use of irreversible sentences. Any of these factors could have altered the processing task, thereby changing subject response. Another possibility is that the task itself was just too simple for normals. Even so, the non-motion verb findings supported Mitchell and Green's verb selectivity hypothesis. Finally, it should be noted that Jones's findings may be in error because he failed to adequately isolate the desired lexical semantic differences between verb types. The controls exercised in the current investigation advocate this position.

Discussion of the Findings in Experiment 2

Experiment 2 was designed to probe more deeply into the influence of the predicate phrase on sentence processing. This idea was taken from Jones (1984) who proposed that directional motion verbs were more difficult to process because of an embedded predicate phrase. To demonstrate this effect, Jones placed the implied preposition in the test phrase and compared aphasic subject's performance on these sentences with motion and non-motion verb sentences. He found that the processing of directional motion verb sentences actually improved as opposed to the scores obtained without the implied preposition. Jones concluded that his brain-injured subjects were unable to utilize the prepositional information stored with the directional motion verb and that surface marking this preposition facilitated comprehension. Hence, the functor served as a cue for these language-impaired individuals.

Normals, on the other hand, would probably not experience the same word retrieval deficit that Jones's patients did, but they could respond to cues provided by various types of prepositions. While function words can supply syntactic or semantic information about a constituent, Just and Carpenter (1987) also argue that the facilitation available may depend upon the saliency of

other cues within the clause. To test these beliefs, the present study manipulated the type of preposition and phrase that followed the verb. This time, only directional motion and motion verbs were utilized. Four possible predicate structures were generated. These included the implied preposition with a directional phrase, the implied preposition with a non-directional phrase, the non-implied preposition with a directional phrase and the non-implied preposition with a non-directional phrase. Since motion verbs do not have a preposition that is presumed to reside in their lexical entry, sentences for this verb type only varied the phrase conditions. This study followed the protocols of Experiment 1 in every way, except for holding the sentence frame constant.

Prepositional Phrase Type Effect

As can be seen in the Results chapter, the manner of assessing comprehension was influential in determining which prepositional phrase types were significantly different. In terms of response latency, only the RSVP results for directional motion verbs reached significance. Here, the implied preposition used in a non-directional sense corresponded to the longest reaction time--a relationship that would appear to indicate a greater processing load associated with that sentence type.

Accuracy data results were not as striking; however, one prepositional phrase contrast was identified. The non-implied preposition utilized in a directional sense was harder to understand than the implied preposition in a directional phrase. These relationships were present in RSVP and approached significance in the SPR data. Apparently, the processing difference noted in the reaction time data does not affect sentence recall.

An additional finding was the statistical significance of several of the motion verb pairwise comparisons in the SPR condition. Since motion verbs do not have implied prepositions, they could not be placed in all of the prepositional phrase types that directional motion verbs could be. So, each motion verb was presented four times in novel sentences--twice in directional phrases and twice in non-directional phrases. One would expect performance within the phrase types to be similar; however this was not the case. The results revealed that one of motion verb--directional phrases was significantly different from the other and one of the sentences in a non-directional sense. The second non-directional phrase approached significance. It would appear then that there is an additional factor in operation, since no differences were expected between the motion verb categories.

Directional motion verbs and prepositional phrases

The present findings indicate that the type of prepositional information that follows the verb can influence its processing. Differences noted between the response measures confirm that comprehension is a complex process; one that is sensitive to the way in which it is measured. For example, when the reaction time and accuracy data are considered for directional motion verbs, it can be noted that subjects selected two separate phrases. Response latency data revealed that use of the implied preposition in a non-directional sense was more difficult to understand than the other phrase types (see Figure 4). This finding was expected since the information stored with a directional motion verb's lexical entry would suggest that a directional phrase should follow. Hence, use of a non-directional phrase with the implied preposition would be analogous to a garden path sentence where the reader initiates one interpretation based on the available cues and has to modify it when he/she notices a need to change the direction of processing (Just and Carpenter, 1987). Further confirmation of this idea is gained when the results are ranked in order of difficulty. Here, it was demonstrated that the non-implied preposition with a non-directional phrase was responded to most quickly; the implied preposition in a directional phrase placed second.

These findings indicate that the subjects found sentences with the expected endings easier to understand. Furthermore, this order of responses would not be predicted by Jones (1984). He would say that the implied preposition in directional sense should be easier to process because of the additional prepositional information stored in the lexical entry. However, the normal participants in this study may have noted the redundancy in this phrase type and paused briefly to assimilate it.

In contrast to the response latency findings, the accuracy data revealed that the non-implied preposition in a directional phrase was the most complex to process. Furthermore, Accuracy 2 results identified more significant pairwise comparisons than Accuracy 1. Perhaps error severity was more characteristic of this phrase type than errors in word recall. These results can be explained in the same way as the reaction time data. To be specific, it is possible that sentence processing was affected because the non-implied preposition may not normally appear in a directional phrase. On the other hand, the movement prescribed by the directional phrase may proceed in a fashion contrary to what is stored with the implied preposition. Hence, any of these unexpectancies could lead to errors in recall. Therefore, while the comprehension measures chose two different prepositional phrase types as being difficult to understand, this discrepancy is easily

reconciled. Both phrase types suggest that presentation in a manner that provides contradictory indicators forces more complex processing. Hence, such cues can impede comprehension.

These phrase type effects also substantiate the premise that the dependent variables sample different aspects of comprehension. Response latency appeared to be responsive to lexical information in that reaction time increased when the implied preposition was utilized in a non-directional sense. To the contrary, accuracy scores (i.e., sentence recall) were higher in the implied preposition condition. Hence, length of time spent "understanding" sentence elements is not the primary factor in determining its complexity. Furthermore, reconstruction of a sentence (i.e., recall) may tap into lexical information in a different way than on-line processing (i.e., response latency). Once again, the definition of comprehension becomes critical.

Motion verbs and prepositional phrases

Differences between prepositional phrase types were noted among several of the motion verb comparisons. However, these findings were evident only in the accuracy data and with the SPR procedure. The results indicated that one of the implied preposition--directional phrase

combinations was more difficult than the other three categories. While not all pairwise comparisons related to this particular phrase type differed at the 0.05 level, all approached significance (see the motion verb means in Figures 7 and 9). There does not appear to be any reason for these findings other than postulation that this group of sentences was more complicated than the others and that this relationship created a hardship related to some factor not measured in this experiment. Given the fact that motion verbs do not have an implied preposition associated with them, one would expect these findings to be non-significant. Perhaps the answer lies in a better understanding of the interaction between the SPR task and the accuracy measures. Nevertheless, it is unclear why this relationship was obtained and why the two lists of phrases in the non-directional sense did not follow the same pattern.

Verb Type Effect

All methods of comprehension testing in Experiment 2 revealed that directional motion verbs were more complex than motion verbs. For example, the reaction time data only displayed a processing difference in RSVP (i.e., directional motion verbs had longer response latencies). Furthermore, motion verb sentences were more accurately

recalled with errors of lesser severity. These findings suggest that the addition of a prepositional phrase induced a processing complexity related to verb type. Since directional motion verbs already have functor information stored with their lexical entry, it is possible that the cues provided by an additional prepositional phrase act to slow sentential understanding. On the contrary, performance with motion verbs was relatively unaffected by prepositional phrase type.

When the subject performance means for verb and preposition type are compared (see Figures 10, 11 and 12), it becomes apparent that directional motion verb categories displayed a broader range of means than motion verbs. This finding may indicate that motion verb performance is more consistent regardless of the functor cue present. Even so, few of the pairwise comparisons across verb type were significant. In fact, only the reaction times associated with the directional motion verb class of implied preposition in a non-directional phrase was significantly greater than all of the motion verb possibilities. In like fashion, consideration of the accuracy data revealed that the directional motion--non-implied preposition in a directional sense was responsible for the directional motion verb--motion verb discrepancy. Naturally, these findings support the prepositional phrase type data described above. However, it is important to emphasize

that the verb type effect noted here is attributable to one specific phrase type, depending upon the test of understanding. This result confirms the idea that functor cues play a role in sentence comprehension.

Comparison of Experiment 2 Results with Other Research

Experiment 2 was devised to permit investigation of the influence of the prepositional phrase on verb type processing. Specifically, the contents of the embedded predicate were varied in such a fashion so as to provide facilitating or contradictory cues to comprehension. Directional motion verbs appeared to be the most susceptible to these prepositional phrase type alterations. This result may be explained by the principle of immediacy of interpretation--i.e., the problem that subjects face in deciding the syntactic role of a word when it is first encountered, before they know what will follow (Just and Carpenter, 1987).

In the present study, two prepositional phrase types were found to be more complex--i.e., the implied preposition in a non-directional sense and the non-implied preposition in a directional phrase--because they yielded the longest response latencies or poorest accuracy scores. Hence, use of directional motion verbs in a "non-standard" way can influence sentential processing. When a

non-directional phrase is used with an implied preposition, the reader's response latency could be increased because he/she is not expecting this type of phrase. Just and Carpenter would state that this type of processing complexity would be evidenced immediately. However, the current findings suggest that RSVP was more sensitive than SPR to these effects. Perhaps the current readers did not recognize the unexpected information until the final stages of processing. Likewise, this idea also would hold true for the accuracy results regarding non-implied prepositions in directional senses. Hence, in both cases, processing was affected because the assumed sentence had to be revised based on preceding sentence cues (Just and Carpenter, 1987).

The present findings also support Jones's (1984) claims about verb and preposition type processing. Jones found that directional motion verbs were the most difficult for his aphasic subjects to understand. While this result was verified by Experiment 1, this second study provided even stronger support. To be specific, all comprehension tests revealed the verb type discrepancy. Since the primary variation between the two current protocols was the presence of prepositional phrases, it can be inferred that the added complexity of the predicate structure highlighted the verb type effect. Furthermore, like Jones, it was noted that surface marking the implied preposition with a

directional phrase also facilitated reading speed and accuracy. Therefore, normal language users demonstrated cognitive processes similar to those noted in a language impaired population. This idea will be discussed further in another section.

Once again, the experimental findings depended upon how comprehension was tested. Different prepositional phrase types were selected by response latency and accuracy scores as being the most complex. While these results appeared contradictory at first, they did support the general purpose of this study, which was to demonstrate the impact of functor cues on sentential understanding.

Since both measures of testing revealed processing differences, this study did not verify the one conducted by Hakes and Cairns (1970). These researchers found that sentence cues did not influence reaction time data and only improved paraphrasing skill. On the other hand, Foss and Lynch (1969) stated that reaction time, and not recall, was the more sensitive technique. While both investigations attempted to resolve the issue of which comprehension measure is best, neither study systematically varied task and stimulus item to permit valid comparisons to past research. Therefore, the discrepancy between procedures may be handled best by carefully controlling task and linguistic information so that specific ideas regarding sentence function and/or meaning can be tested.

The present results also relate to functor use in an aphasic population. Several investigators have proposed that the obligatory nature of a preposition in agrammatic language productions is dependent upon its relationship to the main verb (Friederici, 1982, 1983; Grodzinsky and Zurif, 1984). The cited language-impaired individuals tended to omit functors when meaning was already implied by sentence structure. A similar idea was also noted in the current investigation since processing was affected by reader expectancy of the preposition to follow the verb. However, normals do not react in the same fashion as aphasic individuals, but rather seem to have difficulty when information in the predicate evokes a structure other than that predicted by the verb.

Summary of Experiment 2 Findings

The second experiment was designed to determine the influence of the verb and preposition as cues to comprehension. As demonstrated by the results, the method of testing proved to be influential in determining which phrase type was more difficult to process. Hence, sentential complexity was sensitive to the procedure by which it was measured. In terms of response latency, only RSVP elicited a significant difference attributable to directional motion verbs with an implied preposition and a

non-directional phrase. However, the accuracy measures selected a different classification--directional motion verbs occurring with a non-implied preposition in a directional sense. This finding was present in both RSVP and SPR procedures. While different phrase types were selected by varied procedures, the overall effect was not necessarily contradictory. Both sentence types reflected the kind of cognitive processing that would occur when conflicting cues are present in a stimulus item. Here, unexpected, but not implausible, functor cues are given. Assessment of understanding reflected the subject's uncertainty, as noted by longer response latencies and less accurate sentence reproductions.

A significant verb type effect was also present in this study. As predicted, directional motion verbs were more difficult to process than were motion verbs. This finding was evidenced in the RSVP data and both measures of response accuracy. While this verb type effect was consistently present in all comprehension measures, these results are largely related to specific prepositional phrase categories and should be interpreted with care. Hence, generalizability to other predicate structures is limited to specific linguistic criteria.

The present results also support Jones (1984) by demonstrating that predicate complexity can be altered to affect sentence processing. As Jones predicted, the

normals used in this study found the implied preposition in a directional sense easier to comprehend than most other sentence types. Hence, when this functor was surface marked, reading speed and accuracy were enhanced. Of secondary interest was the finding that motion verbs were easier to process than directional motion verbs. While this relationship also was noted in the first experiment, this time the effect could be linked to changes in the predicate structure.

In summary, the processing of directional motion verbs appears to be influenced by prepositional phrase type. If the information supplied by the lexical entry of the preposition matches that provided by the stimulus sentence, then comprehension is facilitated. On the contrary, if the functor acts in a fashion that is not what the reader expects linguistically, then response latency and recall measures are adversely affected. Therefore, normals do demonstrate that directional motion verbs are more difficult to understand than motion verbs and that this discrepancy can be evidenced when functor cues are present.

Task Effect

Task differences consistently appeared when data analysis was carried out. That is, the reaction times obtained from the SPR procedure were always faster than

those for RSVP. These differences are significant because subject performance on these tasks has not been compared previously. While both techniques assess processing time, the same aspects of cognition are not measured. For example, SPR provides a score for each individual word and is presumed to be more reflective of on-line comprehension, much like the eye movement data (Aaronson, 1984). In contrast, RSVP assesses the amount of time it takes for a subject to "understand" what he/she just read after seeing a series of single words (those of a sentence) flash by on a computer screen. Therefore, the present findings suggest that isolated words seen in succession (SPR) are comprehended more quickly than the wrap-up processing that occurs at the end of a sentence (RSVP). Hence, RSVP scores may be reflective of the linguistic operations that must occur before a sentence is comprehended, while SPR only represents the word reading speed of the subject during phrase presentations.

Differences between tasks also were present in the accuracy scores. In such case, the subjects were able to recall more correct words in the correct order when they were exposed to the SPR procedure; moreover fewer and/or less severe errors were noted. This finding would suggest that SPR permits greater understanding during testing than RSVP. In contrast, the high speed of RSVP presentations appeared to impede subject performance. It is possible

that the subjects felt more confident of their responses using the SPR technique (as noted by the better scores) because they had control over how long they could view any particular word. On the other hand, RSVP forced the subject to rely on his/her syntactic knowledge to fill in information missed during rapid reading. As such, there was a greater possibility for reader error. However, both tasks were equally effective in identifying significant accuracy differences between verb and prepositional phrase type. Hence, the pattern of subject performance within the tasks was similar.

While task proved to be statistically significant in many of the analyses of variance, this factor was not responsible for a verb type difference in Experiment 1. In this study, no significant verb type differences were noted regardless of the stimulus presentation method in use. Therefore, it is suggested that more complex linguistic stimuli were needed to evoke a verb effect or the tasks simply were not difficult enough to elicit the discrepancies when present. On the contrary, RSVP proved to be most sensitive to verb and prepositional phrase types in terms of response latency and accuracy in Experiment 2. SPR yielded significant differences between verb and prepositional phrase type when accuracy scores were considered. Furthermore, only the SPR condition revealed differences between the motion verb categories. Perhaps

individual control of viewing time has an adverse effect on this verb type since no signficant findings were expected. In conclusion, quicker and more accurate comprehension was evidenced during SPR procedures, yet RSVP revealed a greater number of significant differences between stimulus items. Both stimulus presentation procedures were sensitive when paired with the accuracy measures.

When task effectiveness in determining linguistic distinctions is evaluated, the present results are similar to those reported by previous investigators. First, RSVP has been useful in identifying verb complexity and other factors concerning sentence predictability (Forster and Ryder, 1971; Holmes and Forster, 1972; Forster and Olbrei, 1973). The current experiments also support these findings. Secondly, Mitchell (1984) proposed that RSVP may be most useful in fine grain control of temporal presentation. In fact, RSVP was the measure that most consistently revealed processing complexity. Such an effect may be related to stimulus presentation time.

Mitchell and Green (1978) reported that SPR was not particularly sensitive to the effects of cues, especially within simple statements. They reported SPR was actually devised to assess reading rate, which was presumed to be influenced by lexical access and the establishment of a text structure (Mitchell and Green, 1978). While lexical access was a factor in the present investigations, SPR did

not seem to detect any processing differences associated with it. In fact, only when SPR was paired with the accuracy scores were any verb and/or prepositional phrase type differences apparent. Hence, in this instance, SPR was responsive to linguistic cues. However, SPR was included in the present protocols because of the expectation that it would uncover small variations in on-line processing that would be missed by other measures of comprehension (especially RSVP). This hypothesis was not supported. It is proposed that SPR may be most effective in texts as opposed to simple propositions, which is the manner in which it is most frequently utilized. RSVP appears to be more appropriate for the sentence level. Nevertheless, the SPR--motion verb findings of Experiment 2, which are basically unexplainable, provide compelling evidence advocating continued study of the utility of SPR in tasks like the present one.

In summary, SPR performance was superior to that of RSVP; however, the latter technique was more sensitive to processing complexity in terms of response latency. Therefore, it is proposed that RSVP, due to its control of stimulus presentation time, is the preferred technique when using sentence materials. Both procedures revealed significant differences when paired with the accuracy measures. Finally, SPR did not pick up small, on-line

processing variations as was expected. It is possible that SPR is most effective at the paragraph level.

Comparisons Between Normal and Aphasic Language Processing

There is considerable controversy as to the appropriateness of using data obtained from aphasic individuals to make statements about normal cognitive operations. Specifically, researchers are not certain as to how a brain lesion affects language processing. For example, it is possible that the aphasic subject uses strategies invoked by compensatory mechanisms rather than those that are the result of brain damage. By controlling linguistic and task variables, investigators have attempted to isolate the disability and speculate as to how the brain is functioning. However, it must be remembered that the nature and extent of cerebral insults vary among patients and seemingly minor differences in sequelae can influence behavior. Hence, generation of a homogeneous (pathological) population of that type is quite cumbersome, if not impossible.

As would be expected, one of the biggest problems in this area is the selection of the appropriate task. As current and past investigations have demonstrated (Foss and Lynch, 1969; Hakes and Cairns, 1970), the technique utilized can influence subject responses. Thus, in order

to make a direct comparison between disabled and normal language performance, the researcher should use parallel procedures. However, the abilities of the language-impaired individual vary in several ways which hinder this possibility. First, aphasic patients make different types of mistakes than normals. For example, agrammatic participants consistently tend to omit prepositions in their speech attempts, while the college-age readers in the present study produced few errors of omission and leaned toward use of the incorrect preposition or scrambled sentence order. While these results may indicate the desired processing effect, the responses generated may be the product of different cortical mechanisms. Hence, the output may be providing information regarding specific cerebral operations that scientists are unable to identify or even realize their existence. This idea leaves open the possibility that lack of knowledge may result in misinterpretation of results.

Secondly, there are significant task discrepancies between these two groups. These differences are largely related to the comprehension problems noted in most all types of aphasia and the ease with which linguistic disabilities can be demonstrated in brain-injured subjects. Frequently, as in the case of the methodology described in Chapter 2, the techniques utilized with stroke patients are too simple for use with normals--i.e., research based on

them cannot elicit processing errors in normals in the same way as in pathological cases. Therefore, the compatibility among the protocols becomes a significant issue. Again, the end-products may be similar, but the production aspects may vary.

Data from the present investigations can be used to suggest that both college-age readers and Jones's (1984) aphasic subjects respond to verb and prepositional phrase type information in a like fashion. Both groups found directional motion verbs to be more difficult to process and that surface marking the implied preposition improved comprehension. In fact, the latter case even improved performance to levels similar to those obtained with motion verbs. However to test a similar effect in normals, stimulus item changes were made to make the task more difficult and to more comprehensively test the influence of prepositional information. The results revealed that directional motion verbs with non-implied prepositions and non-directional phrases were read just as easily as the implied preposition in a directional sense. Hence, normals did not appear to be responding to predicate complexity but to other linguistic factors, as discussed earlier.

While Jones's subjects did not receive preposition presentations such as those just described in the current protocols, previous literature on prepositional processing in agrammatism (Friederici, 1982, 1983; Grodzinsky and

Zurif, 1984) would suggest that these subjects would be expected to omit the functor if it were essential to conveying the appropriate meaning of the sentence. With this in mind, it is proposed that the differences between the aphasic and normal groups may be related to different cognitive operations. Normals may be reacting to sentence cues and aphasic patients may be having trouble with the syntactic obligations of the preposition. Stated another way, the present experiment tapped into the immediacy of interpretation principle (Just and Carpenter, 1987) concerning cue use and the latter are struggling with word order information (as described by Saffran et al. in 1980a). Both situations can lead to impaired understanding of the target sentence, but the former seems to be more indicative of semantic processing than the latter. Hence, the subject response is affected by processing disturbances at different levels.

In summary, there are several factors which appear to limit the comparison of findings between Jones's subjects and those in the current experiments. First, task and stimuli adaptations may evoke differences in cortical operations. The end-products may appear similar, but the underlying behaviors may differ. Furthermore, the experimental findings could be the result of processing that is halted at varying levels or points in time. Again, performance may be parallel yet not reflect the same

comprehension skills. Therefore, neurolinguistic applications between normal and language disabled individuals should be viewed with caution since protocol alterations made to suit the subject population may also change the type and nature of processing skills involved. As such, these results can serve as points of departure for continued study.

Conclusions

This investigation was conducted to study of influence of word class and functor cues on sentence processing. Certain claims made by Jones (1984) regarding the lexical semantic processing of verbs were examined. For example, he proposed that directional motion verbs were more difficult to understand than motion and non-motion verbs and that this complexity was related to the presence of an embedded predicate in the former verb type. In addition, the validity of postulating normal linguistic function from data obtained from aphasic individuals was considered. Thus, before any conclusions are drawn, it would appear relevant to present a brief review of specific experimental findings.

Of primary importance are the linguistic results. Both studies revealed a verb type processing difference in that directional motion verbs were more difficult to

comprehend than motion verbs. Furthermore, the second indicated that the functor cues tested either facilitated comprehension when they provided information consistent with reader expectation or hindered understanding when it was not predictable. It also could be noted from the Experiment 1 data that complexity was not readily attributable to the presence of an embedded predicate, since the non-motion verbs did perform as anticipated. Likewise, the results of Experiment 2 suggested that prepositional phrase type differences were more related to reader expectancy than the to lexical entries of the verbs. Therefore, it is proposed that directional motion verbs and their predicates may be more difficult to comprehend, but not necessarily for the reasons postulated by Jones (1984).

The other research questions dealt with procedural issues. Reaction time provided important information that was not present in the analysis of correctness of response. This finding advocated the use of multiple techniques to assess the various aspects of comprehension. Even so, differences related to complexity were easier to elicit in tests of understanding. When considering the two recall measures, Accuracy 1 (i.e., the number of correct words recalled in the correct order) consistently produced significant results. Accuracy 2 (i.e., error severity) scores generally followed a similar pattern, but did not always achieve statistical merit. It is possible that the

latter scores would be more beneficial in an analysis of error type and not severity. Finally, RSVP seemed to tap into processing discrepancies more readily than SPR. These facts highlight the need for careful consideration of a definition of comprehension when devising experimental protocols.

In light of the preceding discussion, the following conclusions are presented. First, language results obtained from studies utilizing aphasic individuals may not hold true for normals. As stated before, numerous subject and protocol differences occur when attempts are made to verify results between these groups. In addition, we are unable, at present, to test many aspects of cortical functioning. This makes it difficult to attribute any results to specific brain operations. Therefore, such findings should be used to indicate areas of future study, but not as the bases of linguistic theory. Secondly, comprehension has been noted to be a complex process that is influenced by stimulus construction, method of presentation and test of understanding. These factors interact in such a way as to focus on different aspects of processing. Hence, future studies should attempt to measure comprehension in a variety of ways and then reconcile the findings with one another. As it is, the process of understanding language is still without boundaries.

With respect to verb and prepositional phrase processing, there was a difference between directional motion and motion verbs and this effect was more apparent in the prepositional phrase conditions. These findings suggest that the verb plays an important role in sentence processing and that different verb types may be harder to understand. Finally, it was concluded that the linguistic features tested in these two experimental designs were more evident in the final stages of comprehension (i.e., RSVP scores and sentence recall) than during the stimulus presentation. Hence, verb processing is affected by sentence context, verb type and comprehension measure.

APPENDIX A

SUBJECT INFORMATION

APPENDIX A
SUBJECT INFORMATION FORM

Date: _____ Subject Number: _____

Name:_____ Age:_____

Address: _____

Phone: _____ Birthdate: _____/_____/_____
mo. day year

Please circle yes or no to each of the following questions and answer any questions as indicated.

Do you have a history of any neurological disorders? Yes/No

If yes, please explain: _____

Do you have a history of high fevers as a child? Yes / No

If yes, please explain: _____

Do you have a history of seizure disorders? Yes / No

If yes, Are your seizures controlled by medication? Yes / No

If yes, what type of medication are you taking? _____

DATA ON EVALUATIONS:

Visual Acuity: _____

Reading Grade Level: _____

Reading Speed: _____ wpm

SUBJECT INFORMED CONSENT FORM

Name:
Address:
Phone Number:

Title of Project: The Influence of Verb Semantics on Sentence Processing

Name of Investigator/Academic Title: Ruth A. Huntley, M.A.
Research Associate

_____ agrees to participate in this investigation. Participation will involve the following:

1) Assessing reading grade level and speed.
2) Determining visual acuity.
3) Reading individual words of a sentence as they appear on a computer screen for very brief periods of time.
4) Typing the sentence (or words), as they are perceived, into the computer, as instructed.

I understand that my name will be kept confidential and response forms will be identified by subject number only. This procedure will take place at the Institute for Advanced Study of the Communication Processes (Room 43, Arts and Sciences Building) at the University of Florida at a time convenient for the examiner and subject.

I realize that participation in this study will have no immediate benefit for me. However, I also realize that the information gathered here will be useful in clarifying how semantics and syntax interact to influence sentential complexity. The findings could be utilized to develop reading treatment programs for individuals who have lost the ability to read as the result of a head injury or stroke.

I understand that I am free to withdraw my consent and to discontinue participation in the project at any time without penalty. If I have any questions, I understand that I can contact the principal investigator, Ms. Huntley at 392-2046 from 10-6 weekdays. I have read and understand the procedures described above. I have also received a copy of this description.

_____ _____
(Subject Name and Date) (Witness and Date)

_____
(Investigator and Date)

APPENDIX B

SENTENCE STIMULI

APPENDIX B
SENTENCE STIMULI

EXPERIMENT 1

(The sentences for each verb will be listed in the following order: motion verb, directional motion verb, and non-motion verb).

1. Young children kicked the yellow ball at the party.
   chased
   watched

   As a result, the detectives kicked the wrong car.
   chased
   watched

2. No one in my family came home for Christmas.
   returned
   stayed

   The former governor came here for lunch at noon.
   returned
   stayed

3. Before he left, the janitor closed the broken door.
   replaced
   noticed

   Our teacher closed the cabinets after the last class.
   replaced
   noticed

4. The maid emptied her blue bucket in the sink.
   pushed
   ignored

   My little brother emptied the trash after the dinner.
   pushed
   ignored

5. Henry's secretary sent the important letter to the President.
   left
   forgot

Mary's new boyfriend sent red roses for her birthday.
left
forgot

6. In Hawaii, only good swimmers rode the tall waves.
followed
saw

My Aunt Sally rode that black horse last week.
followed
saw

7. Last year, a jazz band started the holiday parade.
entered
planned

My sister started the dance class at her school.
entered
planned

8. In desperation, the relief pitcher threw a sloppy knuckleball.
inserted
blamed

The women's club threw a large party in October.
inserted
blamed

9. After a rough day, Dad walked home for dinner.
approached
enjoyed

He walked the black dog at the animal shelter.
approached
enjoyed

10. At the birthday party, Jane opened her friend's gift.
took
admired

My mother opened the car in front of her.
took
admired

EXPERIMENT 2

Directional Motion Verbs

1. Leave (out of)

My father's mother left out of the kitchen door.
After the fight, the man left out of spite.
His boss left toward town at the day's end.
The little boy left with his mother for home.

2. Jump (over)

The dogs jumped over the table at the circus.
During the exercise class, they jumped over an hour.
The school girls jumped under the tree at noon.
The cheerleaders jumped with the music during the game.

3. Pass (by)

The children passed by the ice cream shop hurriedly.
Many students passed by the skin of their teeth.
Two boats passed to the left of each other.
The athletes passed at the right time to graduate.

4. Enter (into)

At midnight, two large men entered into the room.
The women entered into a lengthy conversation during lunch.
The party guests entered through the door at nine.
To my surprise, my mother entered with the cake.

5. Penetrate (through)

The grape juice deeply penetrated through the fine fabric.
Her zest for life penetrated through the artist's work.
Before long, the dirt penetrated into the new carpet.
Without warning, thunder and lightning penetrated with great force.

6. Turn (around)

The little red train turned around its final corner.
According to my mother, the leaves turned around August.
The old movie star turned toward the open door.
The student turned in his term paper before five.

7. Revolved (around)

At one time, seven moons revolved around that planet.
Every one of her activities revolved around her work.
According to legend, that moon revolved toward the sun.
In his story, that planet revolved with its moon.

8. Continue (on)

My father continued on that road for ten miles.
The murder trial continued on the following work day.
Finally, the weary racers continued toward the finish line.
The lecture continued for three hours with no break.

9. Pursue (after)

The hunting dogs pursued after the wolves for hours.
He pursued after all our advice to the contrary.
In battle, the tired troops pursued into the forest.
In the movie, the enemy pursued with great persistence.

10. Proceed (on)

At noon, the weary traveler proceeded on the trail.
The Christmas Eve party proceeded on a moment's notice.
She proceeded toward the grocery store in the morning.
Despite numerous questions, the teacher proceeded with the lecture.

Motion Verbs

1. Kick

   At fourth down, the quarterback kicked to their receiver.
   At the theater, the dancers kicked to the music.
   In his fury, the man kicked through the door.
   The white horse kicked after all of the others.

2. Walk

   The woman walked to her apartment at the beach.
   The girls walked to the beat of the music.
   On their vacation, our neighbors walked through that garden.
   Due to an injury, he walked with a limp.

3. Fly

   In the morning, the eagle flew off the cliff.
   After a long day, Bob flew off the handle.
   The President flew to Europe for the peace talks.
   Because of the snow, my relatives flew on Tuesday.

4. Go

   I went out of the room with the teacher.
   She went out of her mind before his death.
   The officers went to the door in a hurry.
   He went through five dress shirts on his trip.

5. Fall

   Fortunately, the prize tiger fell in a large hole.
   At the end, the young man fell in love.
   The coin fell through the crack in the floor.
   At midnight, the lamp fell with a loud noise.

6. Arrive

   Many packages and letters arrived at the old station.
   My parent's train arrived at noon the following day.
   More new people arrived on the bus last Spring.
   All three presents arrived in time for her birthday.

7. Swim

In desperation, the survivors swam for the distant shore.
The young ducks swam for the first time yesterday.
Before their class, the children swam across the lake.
My little sister swam in the school's swim meet.

8. Stop

All of the band members stopped around the corner.
Bidding on the chair stopped around a thousand dollars.
Few parents stopped by the school on Thursday night.
After work, she stopped for bread at the store.

9. Come

Our favorite cousins came on the bus last week.
As expected, the very last package came on Friday.
Few people came to the antique show last Saturday.
To their great surprise, many students came after five.

10. Move

The baby moved toward the picture window very slowly.
The campaign for contributions moved toward its specific goal.
Throughout the game, the players moved around the field.
During the recital, the ballerinas moved with great skill.

Nonsense Sentences (That Could Make Sense)

1. Was the the by bacon paper towel grease absorbed.
2. Lawyers judge's both approaching bench of are the the.
3. Did the high drop baseman fly first ball the.
4. The dinner precede a does football late game party.
5. Children raising school young nation's flag their the were.
6. Seed the cotton by the scattered was farmer old.
7. By admitted universities too students new are many state.
8. Releasing driver door the broken new was truck the.
9. The is rain oak filling spring the water bucket.
10. The visitors castle many old toured ancient by is.

Nonsense Sentences (That Do Not Make Sense)

1. The loss business were the his car was parent's.
2. Now the here the whether was going approach is.
3. Bone the cat dog are toy dropping mouse here.
4. His preceded the by act the was first follows.
5. Do hand question boy after raise class the teacher.
6. Baby his gold ancient has green seen new scattering.
7. How admitted is evidence by lawyer either the judge.
8. Released most was affected cost a the by absorbed.
9. The tank does tire fill bucket water boy gas.
10. Natives house vacation had the following the tour the.

PRACTICE SENTENCES

EXPERIMENT 1

1. Before the party, his mother gathered the baby's toys.
2. Many of the students supported the secretary's unusual decision.
3. A black spider wove a web in the corner.
4. My her rug spare in time one of ball.
5. We enjoyed our recent visit to the textile factory.

EXPERIMENT 2

1. Bob exited out the back door in a hurry.
2. On Thursday, a large crowd gathered for her birthday.
3. Factory a the at whistle work the day started.
4. Slowly, the wooden raft drifted toward the east shore.
5. The Senator continued on his tour of the state.

EXPERIMENT 1

List 1A

1. (b) Before he left, the janitor replaced the broken door.
2. (a) The maid emptied her blue bucket in the sink.
3. Was the the by bacon paper towel grease absorbed.
4. (c) Mary's new boyfriend forgot red roses for her birthday.
5. (a) My Aunt Sally rode that black horse last week.
6. Natives house vacation had the following the tour the.
7. (b) Last year, a jazz band entered the holiday parade.
8. (c) The women's club blamed a large party in October.
9. (b) After a rough day, Dad approached home for dinner.
10. The tank does tire fill bucket water boy gas.
11. (a) At the birthday party, Jane opened her friend's gift.
12. (c) As a result, the detectives watched the wrong car.
13. Lawyers judge's both approaching bench of are the the.
14. Did the high drop baseman fly first ball the.
15. (b) No one in my family returned home for Christmas.
16. (c) In Hawaii, only good swimmers saw the tall waves.
17. The dinner precede a does football late game party.
18. (a) In desperation, the relief pitcher threw a sloppy knuckleball.
19. (b) My mother took the car in front of her.
20. (c) The former governor stayed here for lunch at noon.
21. Released most was affected cost a the by absorbed.
22. (b) My little brother pushed the trash after the dinner.
23. How admitted is evidence by lawyer either the judge.
24. (c) My sister planned the dance class at her school.
25. (a) He walked the black dog at the animal shelter.
26. (b) Young children chased the yellow ball at the party.
27. Baby his gold ancient has green seen new scattering.
28. Children raising school young nation's flag their the were.
29. (c) Our teacher noticed the cabinets after the last class.
30. (a) Henry's secretary sent the important letter to the President.
31. (a) Young children kicked the yellow ball at the party.
32. (c) No one in my family stayed home for Christmas.
33. Seed the cotton by the scattered was farmer old.
34. (a) Before he left, the janitor closed the broken door.
35. (c) The maid ignored her blue bucket in the sink.
36. (c) Henry's secretary forgot the important letter to the President.
37. (b) In Hawaii, only good swimmers followed the tall waves.
38. Do hand question boy after raise class the teacher.
39. (a) Last year, a jazz band started the holiday parade.
40. (b) In desperation, the relief pitcher inserted a sloppy knuckleball.
41. (a) After a rough day, Dad walked home for dinner.
42. His preceded the by act the was first follows
43. Bone the cat dog are toy dropping mouse here.

44. (c) At the birthday party, Jane admired her friend's gift.
45. (a) Mary's new boyfriend sent red roses for her birthday.
46. (c) My little brother ignored the trash after the dinner.
47. (b) Our teacher replaced the cabinets after the last class.
48. (a) The former governor came here for lunch at noon.
49. By admitted universities too students new are many state.
50. (b) As a result, the detectives chased the wrong car.
51. (a) My mother opened the car in front of her.
52. (c) My Aunt Sally saw that black horse last week.
53. (b) My sister entered the dance class at her school.
54. (a) The women's club threw a large party in October.
55. (c) He enjoyed the black dog at the animal shelter.
56. Now the here the whether was going approach is.
57. (b) At the birthday party, Jane took her friend's gift.
58. (c) Young children watched the yellow ball at the party.
59. (c) Last year, a jazz band planned the holiday parade.
60. (b) The maid pushed her blue bucket in the sink.
61. (a) Our teacher closed the cabinets after the last class.
62. Releasing driver door the broken new was truck the.
63. (b) My Aunt Sally followed that black horse last week.
64. (a) No one in my family came home for Christmas.
65. (b) Mary's new boyfriend left red roses for her birthday.
66. The visitors castle many old toured ancient by is.
67. (c) In desperation, the relief pitcher blamed a sloppy knuckleball.
68. (b) He approached the black dog at the animal shelter.
69. (a) In Hawaii, only good swimmers rode the tall waves.
70. (b) The former governor returned here for lunch at noon.
71. (a) My little brother emptied the trash after the dinner.
72. The loss business were the his car was parent's.
73. (a) My sister started the dance class at her school.
74. (b) Henry's secretary left the important letter to the President.
75. (a) As a result, the detectives kicked the wrong car.
76. (b) The women's club inserted a large party in October.
77. The is rain oak filling spring the water bucket.
78. (c) My mother admired the car in front of her.
79. (c) He enjoyed the black dog at the animal shelter.
80. (c) Before he left, the janitor noticed the broken door.

List 1B

1. (c) Before he left, the janitor noticed the broken door.
2. (c) He enjoyed the black dog at the animal shelter.
3. The is rain oak filling spring the water bucket.
4. (c) My mother admired the car in front of her.
5. (b) The women's club inserted a large party in October.
6. The loss business were the his car was parent's.
7. (a) As a result, the detectives kicked the wrong car.
8. (b) Henry's secretary left the important letter to the President.
9. (a) My sister started the dance class at her school.
10. The visitors castle many old toured ancient by is.
11. (a) My little brother emptied the trash after the dinner.
12. (b) The former governor returned here for lunch at noon.
13. Releasing driver door the broken new was truck the.
14. Now the here the whether was going approach is.
15. (a) In Hawaii, only good swimmers rode the tall waves.
16. (b) He approached the black dog at the animal shelter.
17. By admitted universities too students new are many state.
18. (c) In desperation, the relief pitcher blamed a sloppy knuckleball.
19. (b) Mary's new boyfriend left red roses for her birthday.
20. (a) No one in my family came home for Christmas.
21. Bone the cat dog are toy dropping mouse here.
22. (b) My Aunt Sally followed that black horse last week.
23. His preceded the by act the was first follows.
24. (a) Our teacher closed the cabinets after the last class.
25. (b) The maid pushed her blue bucket in the sink.
26. (c) Last year, a jazz band planned the holiday parade.
27. Do hand question boy after raise class the teacher.
28. Seed the cotton by the scattered was farmer old.
29. (c) Young children watched the yellow ball at the party.
30. (b) At the birthday party, Jane took her friend's gift.
31. (c) He enjoyed the black dog at the animal shelter.
32. (a) The women's club threw a large party in October.
33. Baby his gold ancient has green seen new scattering.
34. (b) My sister entered the dance class at her school.
35. (c) My Aunt Sally saw that black horse last week.
36. (a) My mother opened the car in front of her.
37. (b) As a result, the detectives chased the wrong car.
38. How admitted is evidence by lawyer either the judge.
39. (a) The former governor came here for lunch at noon.
40. (b) Our teacher replaced the cabinets after the last class.
41. (c) My little brother ignored the trash after the dinner.
42. Children raising school young nation's flag their the were.
43. Released most was affected cost the by absorbed.
44. (a) Mary's new boyfriend sent red roses for her birthday.

45. (c) At the birthday party, Jane admired her friend's gift.
46. (a) After a rough day, Dad walked home for dinner.
47. (b) In desperation, the relief pitcher inserted a sloppy knuckleball.
48. (a) Last year, a jazz band started the holiday parade.
49. The dinner preced a does football late game party.
50. (b) In Hawaii, only good swimmers followed the tall waves.
51. (c) Henry's secretary forgot the important letter to the President.
52. (c) The maid ignored her blue bucket in the sink.
53. (a) Before he left, the janitor closed the broken door.
54. (c) No one in my family stayed home for Christmas.
55. (a) Young children kicked the yellow ball at the party.
56. Did the high drop baseman fly first ball the.
57. (a) Henry's secretary sent the important letter to the President.
58. (c) Our teacher noticed the cabinets after the last class.
59. (b) Young children chased the yellow ball at the party.
60. (a) He walked the black dog at the animal shelter.
61. (c) My sister planned the dance class at her school.
62. Lawyers judge's both approaching bench of are the the.
63. (b) My little brother pushed the trash after the dinner.
64. (c) The former governor stayed here for lunch at noon.
65. (b) My mother took the car in front of her.
66. The tank does tire fill bucket water boy gas.
67. (a) In desperation, the relief pitcher threw a sloppy knuckleball.
68. (c) In Hawaii, only good swimmers saw the tall waves.
69. (b) No one in my family returned home for Christmas.
70. (c) As a result, the detectives watched the wrong car.
71. (a) At the birthday party, Jane opened her friend's gift.
72. Natives house vacation had the following the tour the.
73. (b) After a rough day, Dad approached home for dinner.
74. (c) The women's club blamed a large party in October.
75. (b) Last year, a jazz band entered the holiday parade.
76. (a) My Aunt Sally rode that black horse last week.
77. Was the the by bacon paper towel grease absorbed.
78. (c) Mary's new boyfriend forgot red roses for her birthday.
79. (a) The maid emptied her blue bucket in the sink.
80. (b) Before he left, the janitor replaced the broken door.

EXPERIMENT 2

List 2A

1. (b) After the fight, the man left out of spite.
2. (a) The dogs jumped over the table at the circus.
3. The is rain oak filling spring the water bucket.
4. (c) In his fury, the man kicked through the door.
5. (c) Two boats passed to the left of each other.
6. The loss business were the his car was parent's.
7. (d) Due to an injury, he walked with a limp.
8. (d) To my surprise, my mother entered with the cake.
9. (b) Her zest for life penetrated through the artist's work.
10. (a) Our favorite cousins came on the bus last week.
11. The visitors castle many old toured ancient by is.
12. (b) The campaign for contributions moved toward its specific goal.
13. (c) The President flew to Europe for the peace talks.
14. Releasing driver door the broken new was truck the.
15. (c) The old movie star turned toward the open door.
16. Now the here the whether was going approach is.
17. (b) She went out of her mind before his death.
18. (a) In the morning, the eagle flew off the cliff.
19. (d) In his story, that planet revolved with its moon.
20. How admitted is evidence by lawyer either the judge.
21. (a) My father continued on that road for ten miles.
22. (c) Throughout the game, the players moved around the field.
23. (b) He pursued after all our advice to the contrary.
24. (a) At noon, the weary traveler proceeded on the trail.
25. By admitted universities too students new are many state.
26. (a) Fortunately, the prize tiger fell in a large hole.
27. Do hand question boy after raise class the teacher.
28. (d) The white horse kicked after all of the others.
29. (c) Before long, the dirt penetrated into the new carpet.
30. (b) My parent's train arrived at noon the following day.
31. (c) Before their class, the children swam across the lake.
32. Seed the cotton by the scattered was farmer old.
33. (c) On their vacation, our neighbors walked through that garden.
34. (d) The athletes passed at the right time to graduate.
35. (a) My father's mother left out of the kitchen door.
36. (b) As expected, the very last package came on Friday.
37. (d) In the movie, the enemy pursued with great persistence.
38. (b) Bidding on the chair stopped around a thousand dollars.
39. Baby his gold ancient has green seen new scattering.
40. (d) He went through five dress shirts on his trip.
41. Children raising school young nation's flag their the were.
42. (c) According to legend, that moon revolved toward the sun.
43. (c) Few people came to the antique show on Saturday.

44. (b) During the exercise class, they jumped over an hour.
45. (a) At midnight, two large men entered into the room.
46. (b) The girls walked to the beat of the music.
47. Released most was affected cost a the by absorbed.
48. (d) The student turned in his term paper before five.
49. (a) At fourth down, the quarterback kicked to their receiver.
50. (d) During the recital, the ballerinas moved with great skill.
51. (b) The murder trial continued on the following work day.
52. His preceded the by act the was first follows.
53. Bone the cat dog are toy dropping mouse here.
54. (d) Because of the snow, my relatives flew on Tuesday.
55. (c) She proceeded toward the grocery store in the morning.
56. (c) In battle, the tired troops pursued into the forest.
57. (a) In desperation, the survivors swam for the distant shore.
58. (d) The cheerleaders jumped with the music during the game.
59. (a) At one time, seven moons revolved around that planet.
60. (d) To their great surprise, many students came after five.
61. The dinner precede a does football late game party.
62. (d) After work, she stopped for bread at the store.
63. (c) The party guests entered through the door at nine.
64. (b) At the end, the young man fell in love.
65. (d) Without warning, thunder and lightning penetrated with great force.
66. (b) At the theater, the dancers kicked to the music.
67. (c) The coin fell through the crack in the floor.
68. (a) The little red train turned around its final corner.
69. (b) Many students passed by the skin of their teeth.
70. (c) More new people arrived on the bus last Spring.
71. Did the high drop baseman fly first ball the.
72. (a) The woman walked to her apartment at the beach.
73. (c) Few parents stopped by the school on Thursday night.
74. (b) The Christmas Eve party proceeded on a moment's notice.
75. (a) I went out of the room with the teacher.
76. (c) His boss left toward town at the day's end.
77. (d) The lecture continued for three hours with no break.
78. Lawyers judge's both approaching bench of are the the.
79. (a) The baby moved toward the picture window very slowly.
80. (b) The young ducks swam for the first time yesterday.
81. (d) Despite numerous questions, the teacher proceeded with the lecture.
82. The tank does tire fill bucket water boy gas.
83. (d) All three presents arrived in time for her birthday.
84. (a) The hunting dogs pursued after the wolves for hours.
85. (c) Finally, the weary racers continued toward the finish line.
86. (b) After a long day, Bob flew off the handle.
87. (b) The women entered into a lengthy conversation during lunch.

88. (d) At midnight, the lamp fell with a loud noise.
89. (a) The children passed by the ice cream shop hurriedly.
90. Natives house vacation had the following the tour the.
91. (c) The school girls jumped under the tree at noon.
92. (d) My little sister swam in the school's swim meet.
93. (c) The officers went to the door in a hurry.
94. (b) Every one of her activities revolved around her work.
95. (a) The grape juice deeply penetrated through the fine fabric.
96. Was the the by bacon paper towel grease absorbed.
97. (b) According to my mother, the leaves turned around August.
98. (a) Many packages and letters arrived at the old station.
99. (a) All of the band members stopped around the corner.
100. (d) The little boy left with his mother for home.

List 2B

1. (d) The little boy left with his mother for home.
2. (a) All of the band members stopped around the corner.
3. Was the the by bacon paper towel grease absorbed.
4. (a) Many packages and letters arrived at the old station.
5. (b) According to my mother, the leaves turned around August.
6. (a) The grape juice deeply penetrated through the fine fabric.
7. Natives house vacation had the following the tour the.
8. (b) Every one of her activities revolved around her work.
9. (c) The officers went to the door in a hurry.
10. (d) My little sister swam in the school's swim meet.
11. (c) The school girls jumped under the tree at noon.
12. The tank does tire fill bucket water boy gas.
13. (a) The children passed by the ice cream shop hurriedly.
14. (d) At midnight, the lamp fell with a loud noise.
15. (b) The women entered into a lengthy conversation during lunch.
16. Lawyers judge's both approaching bench of are the the.
17. Did the high drop baseman fly first ball the.
18. (b) After a long day, Bob flew off the handle.
19. (c) Finally, the weary racers continued toward the finish line.
20. The dinner precede a does football late game party.
21. (a) The hunting dogs pursued after the wolves for hours.
22. (d) All three presents arrived in time for her birthday.
23. (d) Despite numerous questions, the teacher proceeded with the lecture.
24. (b) The young ducks swam for the first time yesterday.
25. Bone the cat dog are toy dropping mouse here.
26. (a) The baby moved toward the picture window very slowly.
27. His preceded the by act the was first follows.
28. (d) The lecture continued for three hours with no break.
29. (c) His boss left toward town at the day's end.
30. (a) I went out of the room with the teacher.
31. (b) The Christmas Eve party proceeded on a moment's notice.
32. Released most was affected cost a the by absorbed.
33. (c) Few parents stopped by the school on Thursday night.
34. (a) The woman walked to her apartment at the beach.
35. (c) More new people arrived on the bus last Spring.
36. (b) Many students passed by the skin of their teeth.
37. (a) The little red train turned around its final corner.
38. (c) The coin fell through the crack in the floor.
39. Children raising school young nation's flag their the were.
40. Baby his gold ancient has green seen new scattering.
41. (b) At the theater, the dancers kicked to the music.
42. (d) Without warning, thunder and lightning penetrated with great force.

43. (b) At the end, the young man fell in love.
44. (c) The party guests entered through the door at nine.
45. (d) After work, she stopped for bread at the store.
46. Seed the cotton by the scattered was farmer old.
47. (d) To their great surprise, many students came after five.
48. (a) At one time, seven moons revolved around that planet.
49. (d) The cheerleaders jumped with the music during the game.
50. (a) In desperation, the survivors swam for the distant shore.
51. Do hand question boy after raise class the teacher.
52. By admitted universities too students new are many state.
53. (c) In battle, the tired troops pursued into the forest.
54. (c) She proceeded toward the grocery store in the morning.
55. (d) Because of the snow, my relatives flew on Tuesday.
56. (b) The murder trial continued on the following work day.
57. (d) During the recital, the ballerinas moved with great skill.
58. (a) At fourth down, the quarterback kicked to their receiver.
59. (d) The student turned in his term paper before five.
60. How admitted is evidence by lawyer either the judge.
61. (b) The girls walked to the beat of the music.
62. (a) At midnight, two large men entered into the room.
63. (b) During the exercise class, they jumped over an hour.
64. (c) Few people came to the antique show on Saturday.
65. (c) According to legend, that moon revolved toward the sun.
66. (d) He went through five dress shirts on his trip.
67. (b) Bidding on the chair stopped around a thousand dollars.
68. (d) In the movie, the enemy pursued with great persistence.
69. (b) As expected, the very last package came on Friday.
70. Now the here the whether was going approach is.
71. (a) My father's mother left out of the kitchen door.
72. (d) The athletes passed at the right time to graduate.
73. (c) On their vacation, our neighbors walked through that garden.
74. (c) Before their class, the children swam across the lake.
75. (b) My parent's train arrived at noon the following day.
76. (c) Before long, the dirt penetrated into the new carpet.
77. (d) The white horse kicked after all of the others.
78. Releasing driver door the broken new was truck the.
79. (a) Fortunately, the prize tiger fell in a large hole.
80. (a) At noon, the weary traveler proceeded on the trail.
81. (b) He pursued after all our advice to the contrary.
82. (c) Throughout the game, the players moved around the field.
83. The visitors castle many old toured ancient by is.
84. (a) My father continued on that road for ten miles.
85. (d) In his story, that planet revolved with its moon.
86. (a) In the morning, the eagle flew off the cliff.
87. (b) She went out of her mind before his death.

88. (c) The old movie star turned toward the open door.
89. (c) The President flew to Europe for the peace talks.
90. (b) The campaign for contributions moved toward its specific goal.
91. The loss business were the his car was parent's.
92. (a) Our favorite cousins came on the bus last week.
93. (b) Her zest for life penetrated through the artist's work.
94. (d) To my surprise, my mother entered with the cake.
95. (d) Due to an injury, he walked with a limp.
96. (c) Two boats passed to the left of each other.
97. The is rain oak filling spring the water bucket.
98. (c) In his fury, the man kicked through the door.
99. (a) The dogs jumped over the table at the circus.
100. (b) After the fight, the man left out of spite.

APPENDIX C

SAMPLES OF THE LINGUISTIC ANALYSIS PROCEDURE

APPENDIX C

SAMPLES OF THE LINGUISTIC ANALYSIS PROCEDURE

1. STIMULUS: Last year, a jazz band entered the holiday parade.
   RESPONSE: Last year, a jazz band entered the holiday parade.

Word length of the stimulus =	9
Word length of the response =	9
Number of correct words in the response =	9
Number of correct words in correct order =	9
Nonstimulus words in response =	0
Number of omissions =	0
Number of additions =	0
Number of duplications =	0
Displacement as found in response =	0
Number of reversals =	0

2. STIMULUS: After a rough day, Dad approached home for dinner.
   RESPONSE: After a tough day, Dad approached home for a dinner.

Word length of the stimulus =	9
Word length of the response =	10
Number of correct words in the response =	8
Number of correct words in correct order =	8
Nonstimulus words in response =	1
Number of omissions =	0
Number of additions =	1
Number of duplications =	1
Displacement as found in response =	0
Number of reversals =	0

3. STIMULUS: Her zest for life penetrated through the artist's work.
   RESPONSE: Her taste of life penetrated the artist's work.

Word length of the stimulus =	9
Word length of the response =	8
Number of correct words in the response =	6
Number of correct words in correct order =	6
Nonstimulus words in response =	2
Number of omissions =	1
Number of additions =	0
Number of duplications =	0
Displacement as found in response =	0
Number of reversals =	0

4. STIMULUS: Do hand question boy after raise class the teacher.
   RESPONSE: Do the hand after class raise the teacher.

Word length of the stimulus =	9
Word length of the response =	8
Number of correct words in the response =	7
Number of correct words in correct order =	5
Nonstimulus words in response =	1
Number of omissions =	1
Number of additions =	0
Number of duplications =	1
Displacement as found in response =	3
Number of reversals =	1

APPENDIX D

ADDITIONAL STATISTICAL TABLES

Appendix D

Additional Statistical Tables

Table D1

Summary Table of the Means and Standard Deviations of the Dependent Variables in Experiment 1

Task = RSVP

N Obs	Variable	N	Minimum	Maximum	Mean	Std Dev
1280	Score 1	1280	0.02	12.28	0.65	0.67
	Accuracy 1	1276	2.00	9.00	7.59	1.98
	Accuracy 2	1276	0.00	20.00	1.94	2.89

Task = SPR

N Obs	Variable	N	Minimum	Maximum	Mean	Std Dev
1280	Score 1	1280	0.10	10.30	0.68	0.57
	Score 2	1280	0.12	4.73	0.50	0.31
	Score 3	1280	0.12	5.02	0.51	0.33
	Score 4	1280	0.10	3.12	0.50	0.33
	Score 5	1280	0.12	4.00	0.51	0.36
	Score 6	1280	0.11	4.83	0.49	0.35
	Score 7	1280	0.12	3.67	0.47	0.27
	Score 8	1280	0.12	3.30	0.46	0.24
	Score 9	1280	0.12	5.73	0.60	0.53
	Accuracy 1	1254	0.00	9.00	7.78	1.90
	Accuracy 2	1254	0.00	20.00	1.78	3.00

Table D2

Summary Table of the Means and Standard Deviations of the Dependent Variables in Experiment 2

Task = RSVP

N Obs	Variable	N	Minimum	Maximum	Mean	Std Dev
1600	Score 1	1600	0.03	55.96	0.71	1.60
	Accuracy 1	1575	1.00	9.00	7.84	1.77
	Accuracy 2	1575	0.00	20.00	1.69	2.73

Task = SPR

N Obs	Variable	N	Minimum	Maximum	Mean	Std Dev
1600	Score 1	1600	0.12	18.14	0.74	0.65
	Score 2	1600	0.13	3.75	0.54	0.31
	Score 3	1600	0.13	5.05	0.56	0.37
	Score 4	1600	0.12	5.20	0.56	0.36
	Score 5	1600	0.13	6.68	0.56	0.43
	Score 6	1600	0.10	6.31	0.56	0.40
	Score 7	1600	0.10	5.08	0.55	0.37
	Score 8	1600	0.11	5.78	0.56	0.44
	Score 9	1600	0.13	11.87	0.70	0.75
	Accuracy 1	1587	1.00	9.00	8.05	1.57
	Accuracy 2	1587	0.00	29.00	1.50	3.05

Table D3

Summary Table of the Means and Standard Deviations of the Dependent Variables Generated for Experiments 1 and 2

Experiment 1

N Obs	Variable	N	Mean	Std Dev
Task = RSVP				
960	Score 1	960	0.57	0.47
Task = SPR				
960	Verb Score	960	0.46	0.29
960	Mean of 9 Scores	960	0.47	0.23

Experiment 2

N Obs	Variable	N	Mean	Std Dev
Task = RSVP				
1280	Score 1	1280	0.59	0.62
Task = SPR				
1280	Verb Score	1280	0.52	0.27
1280	Prep. Score	1280	0.51	0.27
1280	Object of Prep. Score	1280	0.58	0.39
1280	Mean of 9 Scores	1280	0.55	0.25

Table D4

Summary Table of the Two Factor Analysis of Variance Between Sentence Type and Task as reflected by Reaction Time (Experiment 1)

Source	df	Sums of Squares	Mean Square	F value	p
DV: React (SPR = mean of all 9 RT scores)					
Verb	2,1914	0.0643	0.0322	0.24	0.7891
Task	1,1914	2.9993	2.9993	22.09	0.0001**
Verb*Task	2,1914	0.0759	0.0380	0.28	0.7560

** Significant at the 0.05 level

Analysis of the Differences for the Main Effect of Task Utilizing the Bonferroni Procedures.

React

		RSVP	SPR
	Means	0.5666	0.4876
RSVP	0.5666		0.0790**
SPR	0.4876		

MSE = 0.1358, n = 640, df = 1914, Min. Sig. Diff. = 0.0494
** Significant at the 0.05 level (Critical Value = 2.3961)

Table D5

Summary Table of the Three Factor Analysis of Variance Between Task, Verb and Prepositional Phrase as reflected by Reaction Time (Experiment 2)

Source	df	Sums of Squares	Mean Square	F value	p
DV: RT (SPR = verb score)					
Task*Verb*Prep	3,2544	1.5116	0.5039	2.23	0.0829
Verb*Prep	3,2544	2.0589	0.6863	3.03	0.0281**
Task*Prep	3,2544	0.8486	0.2829	1.25	0.2897
Task*Verb	1,2544	1.3067	1.3067	5.78	0.0163**
Task= RSVP, Verb=DMV					
Prep	3,2544	5.5761	1.8587	8.22	**
Task=RSVP, Verb=MV					
Prep	3,2544	0.4443	0.1481	0.66	
Task=SPR, Verb=DMV					
Prep	3,2544	0.0884	0.0295	0.13	
Task=SPR, Verb=MV					
Prep	3,2544	0.0738	0.0246	0.11	

** Significant at the 0.05 level

Table D6

Summary Table of the Three Factor Analysis of Variance Between Task, Verb and Prepositional Phrase as reflected by Reaction Time (Experiment 2)

Source	df	Sums of Squares	Mean Square	F value	p
DV: RT1 (SPR = preposition score)					
Task*Verb*Prep	3,2544	2.2956	0.7652	3.38	0.0175**
Verb*Prep	3,2544	1.4302	0.4767	2.11	0.0972
Task*Prep	3,2544	0.7730	0.2443	1.08	0.3562
Task*Verb	1,2544	1.1902	1.1902	5.26	0.0219**
Task=RSVP, Verb=DMV					
Prep	3,2544	5.5761	1.8587	8.22	**
Task=RSVP, Verb=MV					
Prep	3,2544	0.4443	0.1481	0.65	
Task=SPR, Verb=DMV					
Prep	3,2544	0.0483	0.0161	0.07	
Task=SPR, Verb=MV					
Prep	3,2544	0.3453	0.1151	0.51	

** Significant at the 0.05 level

Table D7

Summary Table of the Three Factor Analysis of Variance Between Task, Verb and Prepositional Phrase as reflected by Reaction Time (Experiment 2)

Source	df	Sums of Squares	Mean Square	F value	p
DV: RT2 (SPR = object of the preposition score)					
Task*Verb*Prep	3,2544	1.4680	0.4893	1.85	0.1368
Verb*Prep	3,2544	2.0541	0.6847	2.58	0.0518
Task*Prep	3,2544	0.5309	0.1770	0.67	0.5721
Task*Verb	1,2544	1.4435	1.4435	5.44	0.0197**
Task=RSVP, Verb=DMV					
Prep	3,2544	5.5761	1.8587	7.01	**
Task=RSVP, Verb=MV					
Prep	3,2544	0.4443	0.1481	0.56	
Task=SPR, Verb=DMV					
Prep	3,2544	0.6557	0.2186	0.82	
Task=SPR, Verb=MV					
Prep	3,2544	0.4825	0.1761	0.61	

** Significant at the 0.05 level

REFERENCES

Agresti, A., and Agresti, B. (1979). Statistical Methods for the Social Sciences. San Francisco: Dellen Publishing Company.

Allen, A., and Kalt, B. (Eds.) (1985). SAS Language Guide for Personal Computers, Version 6 Edition. Cary, NC: SAS Institute Inc.

Aaronson, D. (1984). Computer methods and ecological validity in reading research. Behavior Research Methods, Instruments, and Computers. 16:102-108.

Aaronson, D., and Scarborough, H. (1976). Performance theories for sentence coding: Some quantitative evidence. Journal of Experimental Psychology: Human Perception and Performance. 2: 56-70.

Bever, T. (1970). The cognitive basis for linguistic structures. In: Hayes, J. (ed). Cognition and the Development of Language. New York: John Wiley and Sons, Inc.

Bresnan, J. (1978). A realistic transformational grammar. In: Halle, M., Bresnan, J., and Miller, G. (eds.) Linguistic Theory and Psychological Reality. Cambridge, MA: The MIT Press.

Caplan, D. (1983). A note on the "word-order problem" in agrammatism. Brain and Language. 20:155-165.

Caramazza, A., and Zurif, E. (1976). Dissociation of algorithmic and heuristic processes in language comprehension: Evidence from aphasia. Brain and Language. 3:572-582.

Fischler, I., and Bloom, P. (1980). Rapid processing of the meaning of sentences. Memory and Cognition. 8:216-225.

Fodor, J., and Garrett, M. (1967). Some syntactic determinants of sentential complexity. Perception and Psychophysics. 2:289-296.

Fodor, J., Garrett, M., and Bever, T. (1968). Some syntactic determinants of sentential complexity, II: Verb structure. Perception and Psychophysics. 3:453-461.

Forster, K. (1970). Visual perception of rapidly presented word sequences of varying complexity. Perception and Psychophysics. 8:215-221.

Forster, K. (1981). Priming and the effects of sentence and lexical contexts on naming time: Evidence for autonomous lexical processing. Quarterly Journal of Experimental Psychology. 33A:465-495.

Forster, K., and Olbrei, I. (1973). Semantic heuristics and syntactic analysis. Cognition. 2:319-347.

Forster, K., and Ryder, L. (1971). Perceiving the structure and meaning of sentences. Journal of Verbal Learning and Verbal Behavior. 10:285-296.

Foss, D., and Lynch, R. (1969). Decision processes during sentence comprehension: Effects of surface structure on decision times. Perception and Psychophysics. 5:145-148.

Francis, W., and Kucera, H. (1982). Frequency Analysis of English Usage: Lexicon and Grammar. Boston: Houghton Mifflin Company.

Friederici, A. (1982). Syntactic and semantic processes in aphasic deficits: The availability of prepositions. Brain and Language. 15:249-258.

Friederici, A. (1983). Aphasic's perception of words in sentential context: Some real-time processing evidence. Neuropsychologia. 21:351-358.

Grodzinsky, Y., and Zurif, E. (1984). On the representation of prepositions in agrammatism. Paper presented at the American Academy of Aphasia in Los Angeles.

Gruber, J. (1976). Lexical Structures in Syntax and Semantics. New York: New Holland.

Hakes, D. (1971). Does verb structure affect sentence comprehension? Perception and Psychophysics. 10:229-232.

Hakes, D., and Cairns, H. (1970). Sentence comprehension and relative pronouns. Perception and Psychophysics. 8:5-8.

Heeschen, C. (1980). Strategies of decoding actor-object-relations by aphasic patients. Cortex. 16:5-19.

Holmes, V., and Forster, K. (1972). Perceptual complexity and underlying sentence structure. Journal of Verbal Learning and Verbal Behavior. 11:148-156.

Jackendoff, R. (1972). Semantic Interpretation in Generative Grammar. Cambridge, MA: M.I.T. Press.

Jones, E. (1984). Word order processing in aphasia: Effect of verb semantics. In Rose, F. (ed.) Advances in Neurology, Vol. 42: Progress in Aphasiology. New York: Raven Press.

Joyner, S. (Ed.) (1985). SAS/Stat Guide for Personal Computers, Version 6 Edition. Cary, NC: SAS Institute Inc.

Just, M., and Carpenter, P. (1987). The Psychology of Reading and Language Comprehension. Boston: Allyn and Bacon, Inc.

Just, M., Carpenter, P., and Woolley, J. (1982). Paradigms and processes in reading comprehension. Journal of Experimental Psychology: General. 111:228-238.

Miller, G. (1956). The magical number seven, plus or minus two: Some limits on our capacity for processing information. Psychological Review. 63:81-97.

Miller, G. (1972). English verbs of motion: A case study in semantics and lexical memory. In: Melton, A. and Martin, E. (eds.) Coding Processes in Human Memory. New York: John Wiley and Sons.

Mitchell, D. (1984). An evaluation of subject-paced reading tasks and other methods for investigating immediate processes in reading. In: Kieras, D. and Just, M. (eds.) New Methods in Reading Comprehension Research. Hillsdale, NJ: Lawrence Erlbaum Associates, Publishers.

Mitchell, D., and Green, D. (1978). The effects of context and content on immediate processing in reading. Quarterly Journal of Experimental Psychology. 30:609-636.

Potter, M. (1984). Rapid serial visual presentation (RSVP): A method for studying language processing. In: Kieras, D. and Just, M. (1984). New Methods in Reading Comprehension Research. Hillsdale, NJ: Lawrence Erlbaum Associates, Publishers.

Raygor, A. (1970). "Reading Test" from the McGraw-Hill Basic Skills System. Monterey, CA: McGraw-Hill Book Company.

Saffran, E., Schwartz, M., and Marin, O. (1980a). The word order problem in agrammatism: Production. Brain and Language. 10:263-280.

Saffran, E., Schwartz, M., and Marin, O. (1980b). Evidence from aphasia: Isolating the components of a production model. In: Butterworth, B. Language Production. London: Academic Press.

Schwartz, M., Saffran, E., and Marin, O. (1980). The word order problem in agrammatism: Comprehension. Brain and Language. 10:249-262.

Slobin, D. (1966). Grammatical transformations and sentence comprehension in childhood and adulthood. Journal of Verbal Learning and Verbal Behavior. 5:219-227.

Smith, S., and Mimica, I. (1984). Agrammatism in a case-inflected language: Comprehension of agent-object relations. Brain and Language. 21:274-290.

Titmus Vision Tester. (1968). Titmus Optical Co., Inc. Petersburg, VA.

von Stockert, T. (1972). Recognition of syntactic structure in aphasic patients. Cortex. 8:323-334.

von Stockert, T., and Bader, L. (1976). Some relations of grammar and lexicon in aphasia. Cortex. 12:49-60.

Zurif, E., and Caramazza, A. (1976). Psycholinguistic structures in aphasia: Studies in syntax and semantics. In Whitaker, H. and Whitaker, H. (eds.) Studies in Neurolinguistics, Vol. 1. New York: Academic Press.

Zurif, E., Green, E., Caramazza, A., and Goodenough, C. (1976). Grammatical intuitions of aphasic patients: Sensitivity to functors. Cortex. 12:183-186.

BIOGRAPHICAL SKETCH

Ruth Ann Huntley, daughter of Harlan Harrison and Marjorie (English) Huntley, was born in Sheboygan, Wisconsin, on May 12, 1958. She was educated in the public schools in Pennsylvania and Virginia. In May, 1976, she was graduated from Springwood Academy in Lanett, Alabama. She attended LaGrange College on an early admission basis in lieu of her senior year in high school. Deciding to study speech/language pathology, she completed her Bachelor of Science degree with Honors at the University of Virginia in May, 1979, and her Master of Arts at Auburn University in June, 1981. She then worked for West Georgia Rehabilitation Clinic in LaGrange, Georgia, and The Memorial Hospital in Danville, Virginia.

In August, 1982, she returned to graduate school to pursue her Doctor of Philosophy degree at the University of Florida. Since then, she has worked as a clinical supervisor, Level II Trainee at the Gainesville Veteran's Administration Medical Center and as a research associate, at the Institute for Advanced Study of the Communication Processes. After graduation in December, 1987, she plans to continue as a post-doctoral student with Dr. Hollien and as a consultant for Forensic Communication Associates.

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Harry Hollien, Chairman
Professor of Speech and Linguistics

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Ira Fischler
Professor of Psychology

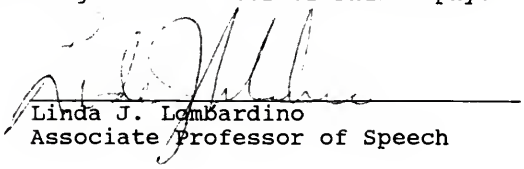
I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Jean Casagrande
Professor of Linguistics

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Leslie J. Gonzalez Rothi
Assistant Professor of Speech

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.



Linda J. Lombardino
Associate Professor of Speech

This dissertation was submitted to the Graduate Faculty of the Department of Speech in the College of Liberal Arts and Sciences and to the Graduate School and was accepted as partial fulfillment of the requirements for the degree of Doctor of Philosophy.

December, 1987

Dean, Graduate School